VEM
Bigelow

INSTALLING MANAGEMENT
IN
WOODWORKING PLANTS

BY

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NEW YORK
THE ENGINEERING MAGAZINE COMPANY
1920

PRESS OF
BRAUNWORTH & CO.
BOOK MANUFACTURERS
BROOKLYN, N. Y.

To My Father

ERVIN ELLIOTT BIGELOW

AN ENGINEER OF THE OLD SCHOOL

WHOSE INTEREST HAS BEEN A CONSTANT INSPIRATION

PREFACE

THE author's purpose in preparing this book has been twofold; first, to express in a general way his ideas as to the application of the principles of scientific management to industry in general, and second, to outline in some detail the application of these principles to the specific problems of the woodworking industry.

As outlined in the first chapter, the woodworking industry is peculiar in many ways and as a result demands an entirely different application of the principles of scientific management than metalworking. The industry as a whole is decidedly non-technical and unstandardized. The equipment is undeveloped and in the average plant maintenance receives comparatively little attention. Any very highly developed scientific mechanism is therefore inapplicable to the industry, and for the same reason, in applying the functional type of organization, the application must be considerably modified and simplified. During the several years of experience of the author and his associates in applying scientific management to this industry, it has been his purpose to confine his recommendations and installations largely to fundamentals, hoping that after these have operated for some time that refinements of management and operation similar to those usually applied in the metalworking industry may be ultimately developed.

Considerable space is devoted to the standardization of the product itself, as the utility of interchangeable parts and of design which will assist manufacturing conditions has been little considered in this industry in the past.

The selection, handling, storing, drying, and utilization of lumber is practically as important to the woodworking industry as is the control of labor, and in the chapters devoted to these subjects description is given of the layout of the physical requirements in the way of trackage and truck facilities for storing and transporting it. Short descriptions are also given of the principal types of kilns commonly used for the drying of lumber, together with the theory of wood drying. Two common

methods for controlling the movement of the lumber and the maintenance of dryness standards are likewise described and illustrative bonus rates shown for the manual handling of the lumber.

Purchasing and storing of material in general are treated rather briefly, as aside from lumber the volume of material used in a woodworking plant is not large.

The type of planning department required for a typical furniture industry is also described in detail, with particular reference to the stationery and forms required, the control boards, and the general method of procedure. Simplification of clerical methods by the means of graphic charts is suggested. The fundamental theory upon which this planning department is devised is based upon the ordering of the product through the plant to meet the requirements of "shaped parts" and "machined parts." Many a woodworking plant suffers from the impossibility of controlling its product simply because the method of ordering the manufacture creates a large job shop in place of a manufacturing plant. By the use of interchangeable parts wherever possible and the manufacture of these in large quantities through cutting and shaping operations, their storage in what is known as a "shaped-stock" storeroom, their withdrawal from this stock for the individual fitting or machining operations required by the different units of product, the storage of these machined parts in a "machined-stock" storeroom from which they are withdrawn for the assembly or driving up operations, the advantage of gross manufacture may be realized, if the planning mechanism is properly devised, without danger of overstocking obsolete parts or units of the product. The author has applied this method of woodworking control to the manufacture of chairs, tables and miscellaneous furniture, and going to a far extreme, boxes.

The physical reorganization of a plant consisting of the rerouting and relocation of the equipment is also discussed. In this connection not only are the principles outlined upon which the reorganization is based, but the method and the routine for putting the changes through efficiently are also presented.

The author has likewise endeavored to outline his recommendations as to the standardization of shop practice in sufficient detail to enable the management of a small shop to install the methods suggested. Charts and tables of operation standards and time allowances are included wherever operations are

common enough to apply in the average factory. Details of machine design and location are given for major operations, such as cutting-off, ripping, seat making, etc.

The fundamental lack of data as to the proper cutting of wood is discussed, together with the elements of a theory for the cutting of lumber evolved during several years of observation of cutting times for major operations.

The subjects of tool and fixture control, repair control, waste control, and the power problem in the average woodworking plant are discussed in short chapters.

The handling of the labor problem in a woodworking plant is discussed from the function of employment and certain practical applications of social service, and other general considerations, through to the remuneration of the labor by a special plan of wage payment. The establishment of the labor standards as a basis for this wage payment is covered by a brief description of simple time-study methods such as may be applied by a member of the local personnel of a woodworking plant.

Finally, the subject of cost acounting is presented in considerable detail. The accumulation of material and labor costs in the plant, the handling of indirect or overhead costs by means of a reserve or burden account, and the statistical details necessary to apply the figures to the various units of product are each discussed at some length. Charts of accounts and a general description of the uses of inter-controlled works and private ledgers are presented to illustrate the control and proving of costs by their absorption into the general accounting. The conclusion outlines the results which may be anticipated from installation of the methods described.

The author wishes to acknowledge the assistance of Mr. Harold A. Marvin in the preparation of the chapter on cost accounting, and also to acknowledge the careful editorial work and helpful criticisms of Mr. L. P. Alford, editor of *Industrial Management,* in connection with the publication of a large portion of the present text in that journal.

CARLE M. BIGELOW.

BOSTON, MASS.,
June, 1920.

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INSTALLING MANAGEMENT IN WOODWORKING PLANTS

INTRODUCTION

SEVERAL years ago an association of manufacturers composed of about sixty members, whose factories were engaged in manufacturing a similar type of furniture, opened a discussion regarding the necessity for a uniform plan of cost accounting. In order to demonstrate the necessity for such work, the secretary of the association had specifications drawn up for a standard type of an article of furniture manufactured by practically every member, and he submitted these specifications to the various members with the request that they figure the cost of manufacture. The replies to these inquiries received by the secretary showed a variation of over one hundred per cent between the lowest and highest cost calculated by the various members.

As a result of this investigation, the association not only authorized the organization with which the author is connected to devise and install for it a uniform plan of cost accounting, but it also brought about a general inquiry by individual members into the effectiveness of their own businesses and this in turn led to the introduction of scientific management in the plants of several of the members. With this work as a nucleus, similar work has been done in practically every branch of the woodworking industry. All of the engineering and management features have been executed under the supervision of the author and he has thus been afforded an opportunity to judge from actual experience the efficacy of the application of the various fundamentals of scientific management as applied to the woodworking industry. Each phase outlined in these discussions has been actually applied in one or several installations in woodworking factories, the author having selected and outlined herein the various practices which have proved most effectual. The majority of the illustrative examples have been taken from chair manufacturing practice with which the author is particularly familiar.

In addition to discussing the application of scientific management to woodworking, it is also the purpose of the author to outline the principal phases of the technique of the general application of the principles of scientific management as viewed by himself and associates, and which he believes apply fundamentally to any industry.

CHAPTER I

TRADITIONAL PECULIARITIES OF WOODWORKING MAKING SCIENTIFIC MANAGEMENT ESSENTIAL

THE utter lack of true cost data in the past by the woodworking industry has in a large degree been the principal cause of its difficulties. Due to this lack and the resulting practice of flagrant price cutting, a competitive condition resulted which so reduced the margin of profit that practically no surplus was available for improving, or in fact, even maintaining plant and equipment. Practically the only changes in plant or equipment made were to counteract actual breakdowns or very noticeable depreciation. Often such matters as leaky roofs were allowed to go without repair until such a condition became absolutely intolerable. Machinery was patched up time and time again in the cheapest possible manner, often sacrificing operating efficiency to prevent expensive cost of repair. Proper cleaning and sanitary conditions were of necessity utterly neglected and five years ago the average factory of the particular branch of the woodworking industry under discussion was in a very lamentable physical condition.

Figures 1, 2 and 3 are good illustrations of conditions prevalent at that time and which are unfortunately still common in many instances. These photographs indicate the absolute impossibility of effectual operation under such physical conditions.

Effect of These Conditions on Woodworking Machinery

Not only did this condition of ruinous competition have a direct effect upon the productive capacity of the factories, but it also injected a further unfortunate condition. As the woodworkers could not afford to buy any machinery that was not absolutely needed and since it must then be at the least possible expense, there was little incentive toward the design and development of improved or automatic woodworking machinery. As a

result, such machinery, until the last two or three years, underwent practically no improvements, the majority being constructed in a very cheap and inferior way as the machine manufacturer had to operate under practically the same condition as the furniture manufacturer, since the small margin of the one necessarily meant a small operating margin for the other. Therefore average woodworking machinery is far behind in inventive de-

FIGURE 1.—Prevailing Conditions in a Woodworking Shop

velopment, design, and construction when compared with metalworking or textile machinery.

VARIETY OF PRODUCT

Furniture, like clothing, is constantly changing in style, and this continual changing results in a factory having to handle a large variety of product within a comparatively short period of time. By no means is this variety as difficult to cope with, however, as in many metalworking plants, for while there actually is a large variety, the similarity of different parts and designs reduces this variety very materially, and the slight use of

special equipment does not involve the constant redesign of expensive tools and equipment as in metalworking. The average woodworking manufacturer, however, would not concur in this opinion.

A constant difficulty before the minds of the woodworkers regarding any attempt to carry out standardization of product or manufacturing methods is this question of variety. The author is of the opinion that the average woodworking manager really

FIGURE 2.—Typical Example of Lack of Order in a Woodworking Shop

believes that his particular industry has to cope with a larger problem of variety and manufacture than in any other industry. With this opinion regarding variety, however, a rather peculiar condition has arisen. Instead of making an attempt to control or reduce the effect of variety of product, the woodworker has apparently considered it an absolutely necessary evil and very few have made any attempts to reduce variety through standardization of design, interchangeable parts, or limitation of line. This belief in the unavoidability of variety and failure to make any attempt to control it is not only a stumbling block in the way of scientific management, but it has also been the means of holding back the design of woodworking machinery, inasmuch as the

manufacturer has considered automatic machinery impossible to adapt to the necessarily large variety of his product.

Little Regard for Economic Material Utilization

Until quite recently, lumber could be obtained very cheaply and most means which would have conserved its utilization involved more expense than the original cost of the material. Furthermore, any spoiled parts or waste could be utilized as fuel.

FIGURE 3.—Congestion of Machines and Stock in a Woodworking Shop

Through the years there has thus been a failure to comprehend the value of utilizing material economically.

Of late years lumber has increased in value until it has now reached a price which makes it absolutely essential that it be handled economically. However, not only have many manufacturers failed to grasp this point but due to the years of the lack of such requirement the creating of a proper regard for this utilization is extremely difficult. This question will later be covered in detail.

LACK OF TECHNICAL TRAINING AMONG MANAGERS

A fact quite difficult to explain upon cursory examination is that in the entire woodworking industry there are few men of technical training. The progress of the metalworking industry can be traced to the prevalence of engineers in the organization of that industry, and to-day practically no metalworking plant of any size whatsoever is without its engineering department.

The author has had dealings with over sixty woodworking plants, but in not a single instance has he discovered any sign of a real engineering department, and in the large majority there has not been a single individual connected with the industry who has had the benefit of an engineering education. The reason for this is perhaps to be found in the very traditional manner in which woodworking is conducted. There is no appeal to the young engineer to enter the industry as the traditional lines and methods along which it has been prosecuted are at utter variance with his scientific and progressive training. For instance, even in factories having continually changing designs, the usual procedure is not to provide detailed drawings, sketches, or blue prints of the product, but to operate wholly from wooden patterns or models, which is obviously as "rule of thumb" a procedure as is possible to imagine.

A further detail of similar procedure, or perhaps a result of the above, is the great variation in dimension of the various lots of the same part of a unit of furniture. The result of this is, of course, an utter lack of interchangeability of parts, the same being enhanced by the common procedure of setting up machines by means of the above mentioned patterns instead of by gauges or templets and necessarily somewhat influenced by the presence of variable quantities of moisture in the wood. In other words, the means utilized in metalworking factories by engineers to standardize and cheapen methods of manufacture is not applied to woodworking, and the industry investigated broadly is found to be wholly traditional in its policy. An amusing method of avoiding ill effects of interchangeability of parts is the common practice of allowing the same operative to both machine and assemble furniture, which is based upon the supposition that if he is to put it together he will surely machine it correctly. As a matter of fact, is allows him, if machined incorrectly, to destroy and replace the defective parts, or by various means to patch them

up in the method of assembly. The author has seen many an hour spent by an assembler in sawing up incorrectly machined parts in order that they might not be identified in the boiler-house.

Interest of Managers in Merchandising

Another factor which has tended to prevent improved manufacturing methods is the fact that the majority of managers of woodworking industries, at least those with whom the author has come into contact, are more interested in merchandising than they are in manufacturing. While in other industries the best brains of the organization are applied to both manufacture and disposal of the product, in the woodworking industry it is a legitimate criticism to state that manufacturing is neglected, and the attention of the more important executives is usually directed towards buying and selling lumber and in disposing of their product.

In more than one instance where the effectuality of a woodworking concern has been investigated it has been found that while the business as a whole showed a profit, the actual manufacturing was carried on at a loss, the manager more than offsetting this loss by the profit he has realized in trade in lumber. Such merchandising profit is of course not to be deplored, but if similar additional intelligence had been brought to bear upon the manufacturing phase of the business as well, the final profit would have been much increased.

This is not stated in a spirit of criticism. Many of these managers are unusually capable business men. But instead of devoting a proper share of their attention to the actual operation of their plants they leave this to incapable subordinates, who are often good workmen but lacking in breadth of judgment and creative ability to control the plant or to develop efficient manufacturing processes.

An illustration of the clever merchandising genius of these managers is recalled. This man found that he could not dispose of several hundred juvenile chairs of a certain design, which he usually sold for about seventy-five cents each. Noting some very novel Mother Goose cretonne in New York, he purchased a supply and had a small portion of a yard tacked over the back and seat of the chairs. The cost was about ten cents per chair and he finally sold every one of them at two dollars each. The same

creative ability applied to the operation and development of the manufacturing plant is necessary.

We therefore have to deal in the installation of scientific management in woodworking plants, with an industry utilizing traditional rule of thumb methods in nearly all its procedures, with practically an absence of technically trained managers, an utter lack of standardized procedures, and quite often a real neglect of the necessities of the manufacturing phase of the business. Furthermore, we have to deal with an industry often crippled for funds and with plants poorly designed, even in a deplorable physical condition and with inadequate machinery and equipment. These fundamental facts should be borne in mind in the following discussions of the application of scientific management to this industry.

CHAPTER II

Organization and Its Installation

THE first step in the actual reorganization of a woodworking plant after the preliminary survey, which in most cases is made and accepted by the Board of Directors as a basis of establishing the necessity for a reorganization, is a study of the present organization of the business and the creation of an organization chart which shows graphically the functions of the various members. Such a chart for a typical woodworking organization is shown in Figure 4. In studying this chart it should be borne in mind that a large number of woodworking plants have a total personnel seldom exceeding three hundred, and a complete organization with separate individuals for each of the various functions of the business is therefore usually impossible. For instance, the assignment of purchasing to the president, and advertising to the treasurer would seem impractical in most industries, but considering the size of the average woodworking industry it has been found that such assignment is logical and practical. Reading Figure 4 concurrently, the plan of organization outlined is as follows:

Stockholders. The principal directive function of the stockholders is to elect a Board of Directors.

Board of Directors. The Board of Directors elects the President and Treasurer, the two active officers of the concern, and has a general control over the business.

President. The President, who is responsible to Board of Directors, is the executive head of the organization, and is directly in charge of manufacturing and purchasing. In this connection, the President should bear in mind that the effectiveness of the manufacturing processes of the business is a prime factor in the success of the project. Through the purchasing he will find an outlet for the common desire of woodworking officials to deal in lumber, but he should be made to realize that the business is a manufacturing project rather than a merchandis-

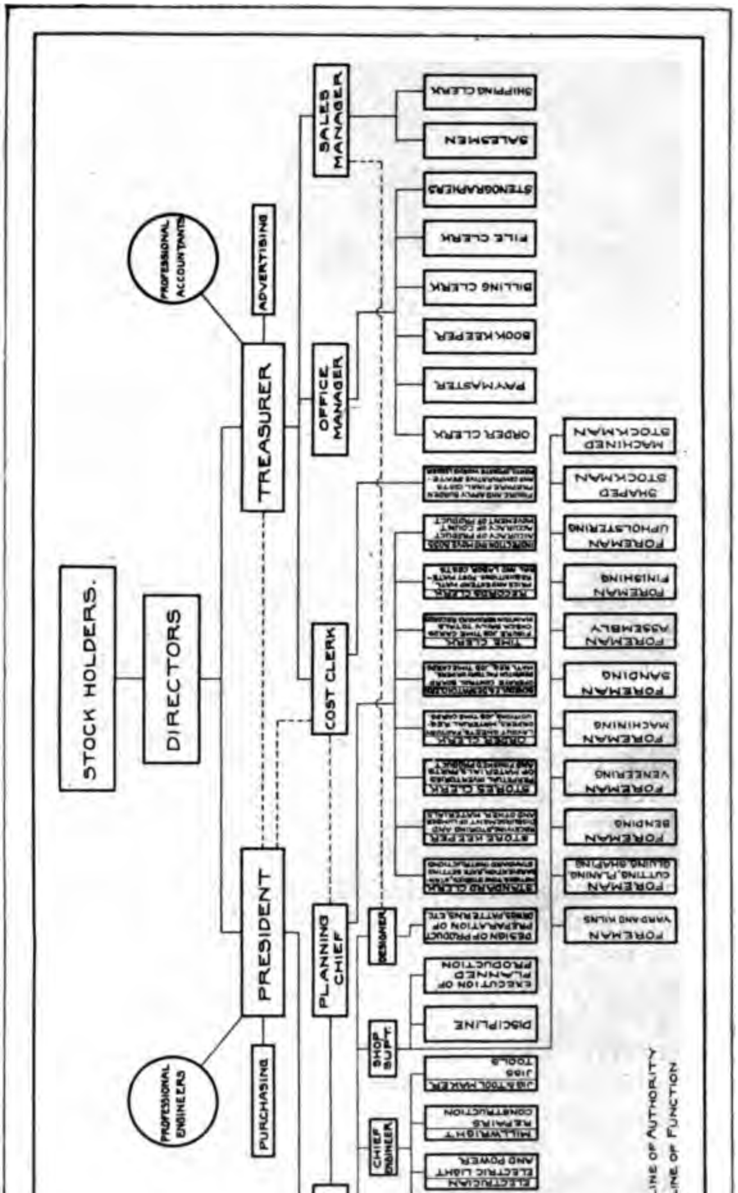

FIGURE 4.—Diagram of Organization for a Woodworking Shop

ing one. As mentioned in Chapter I, the principal official of a woodworking plant too often devotes his energies towards merchandising to the detriment of the manufacturing.

The assignment of purchasing to the President does not involve a large amount of routine work. The actual mechanism can be carried on by a clerk as excepting lumber the purchasing does not aggregate a large amount. However, responsibility for the procurement of the proper grades of lumber at legitimate prices is such an influencing factor upon the final success of the business that its control naturally devolves itself upon the principal official.

The President, as the executive head of the business, is usually in charge of the reorganization, and the professional engineers retained for this purpose are usually responsible to him.

TREASURER. The Treasurer, who is responsible to Board of Directors, is in charge of the merchandising, office, accounting, sales, and advertising. This makes a good division of responsibility between him and the President, the latter being responsible for the manufacturing or internal work of the company together with the procurement of materials which is closely allied to the manufacturing, while the Treasurer is responsible for the accounting and publicity which represent the external work and the connection between the external and internal.

The necessary retainment of professional accountants for periodic audits and organization of accounting methods should be also subject to the Treasurer.

WORKS MANAGER. The Works Manager, who is responsible to President, is directly in charge of the manufacturing and operation of the plant. Often he will act as the actual shop superintendent, depending upon the size of the plant. There is shown in the chart, however, his assistance by a Shop Superintendent, as in practically every woodworking plant investigated there was found a Superintendent and an Assistant Superintendent whose duties roughly correspond to those of the Works Manager and Shop Superintendent, as outlined below. The Works Manager therefore has the following five assistants:

- Planning Chief (see page 12)
- Employment Manager
  - Hires all employees
  - Maintains records covering the time of employment, physical condition, wages, and effectuality of all employees

Studies methods and makes recommendations to the Works Manager for the reduction of labor overturn

In charge of protection through the watchmen.

Shop Superintendent

In charge of shop discipline and execution of production laid out by the Planning Department through the foremen of the following departments:[1]

- Yard and Kilns
- Cutting, Planing, Gluing, and Shaping
- Bending
- Veneering
- Machining
- Sanding
- Assembly
- Finishing
- Upholstering
- Shaped Stockman
- Machined Stockman

Chief Engineer

In charge of heat, light, power, maintenance, construction, and tool and jig making, assisted by the following:

- Engineer
  - Steam power and heat
- Electrician
  - Electric power and illumination
- Millwright
  - Repairs and construction
- Jig and Tool Maker
  - Makes all jigs and tools, designed by Chief Engineer in conjunction with Shop Superintendent.

Designer

Design of product

Preparation of drawings, patterns, etc.

PLANNING CHIEF. The Planning Chief, who is responsible to Works Manager, is in direct charge of the Planning Depart-

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[1] In small factories these foremen can often be "working bosses" if the operation of the plant follows the plan described. The foremen, except in very large woodworking plants (which are few), serve under this plan merely as the representative of the Shop Superintendent for disciplinary purposes; production and quality being largely controlled by the Planning Department. This is usually essential as the average grade of foremen found in woodworking factories are seldom capable of assuming broader duties effectively.

ment which plans and controls all production, issuance of factory orders, maintenance of necessary manufacturing information and records, control of wage payment, figuring of time cards, material and stock requisitions and inventories, compilation of direct labor and material cost data, quality of product, and general effectuality of the plant operations with the assistance of the following:

Standards Clerk
- Motion and time study
- Rate setting
- Standardization of product and operations
- Preparation of standard instructions.

Storekeeper
- Receiving, storing, and disbursement of lumber and all other materials.

Stores Clerk
- Perpetual inventories of materials, parts, and finished product.

Order Clerk
- Maintenance of layout sheets, preparation of factory orders, material requisitions, and job time cards, and maintenance of order summary, and lumber control.

Schedule and Despatch Clerk
- Maintenance of control boards
- Dispatching of factory orders, material requisitions, and job-time cards into factory, and adjustment of control boards upon their return.

Time Clerk
- Figuring of all job-time cards, checking same against in and out cards, and maintenance of workmen's records which serve as a basis of preparation for the payroll.

Records Clerk
- Prices and extends material requisitions and posts direct material and labor cost to cost summaries.

Inspection and Move Boss
- The Inspection and Move Boss verifies through his assistants the accuracy of production records of all major operations and is responsible for the entry of correct production data on job time cards. At the same time the production is verified his assistants are to verify the accuracy of the product by inspection against ad

quate patterns or gauges and throw out all culls. When accuracy and count have been verified he is responsible for product being moved to proper location for the subsequent operation.

COST CLERK. The Cost Clerk, who is responsible to the Treasurer with a functional relation to the President, receives the accumulated direct labor and material charges from the Planning Department, adds the proper burden to them, and prepares therefrom final cost reports, comparative statements, etc. The Cost Clerk operates the "works ledger" described on page 279.

OFFICE MANAGER. The Office Manager, who is responsible to the Treasurer, is responsible for the office and all functions thereof. He is assisted by the following individuals whose duties are self-evident:

Order Clerk
Paymaster
Bookkeeper
Billing Clerk
File Clerk
Stenographers

SALES MANAGER: The Sales Manager, who is responsible to the Treasurer, is responsible for selling the product and the shipping. Responsible to him are the:

Salesmen
Shipping Clerk

INSTALLATION

With the completion of the organization chart and its approval by the representative appointed by the Board of Directors (usually the President), the gradual instruction of the personnel of the organization in their new duties as they are worked out, must be undertaken. This is accomplished first by personal conferences and demonstrations, and secondly by the use of carefully prepared general instructions the use of which is outlined in the following instruction actually used on contracts.

HOW TO WRITE AND USE GENERAL INSTRUCTIONS

Broadly speaking there are two methods that may be followed in instituting any standard practice. One is to depend

upon verbal instructions; the other, upon written instructions. The former, especially in the form of conferences of heads of departments, is of the greatest help in securing co-operation of those who will be called upon to execute the details of the new practice and in serving to explain its advantages and clear up misunderstandings. Such conferences will do much toward offsetting the impersonal character of an order in writing.

To be lastingly effective, however, personal instructions should be backed up by written instructions hereafter referred to as general instructions or simply instructions. *Verbal instructions are more easily forgotten, disregarded, or misunderstood than orders in writing and do not carry the same weight as a typewritten standard practice instruction signed by some official of the company.* Moreover, in personal instructions there is much greater liability of forgetting to explain some important detail.

The policy of avoiding verbal orders is not, however, all that is necessary. That full benefit may be derived from standard practice instructions there should be established some regular procedure providing for their preparation, approval, and issuing, otherwise there is danger that foremen and heads of departments will find themselves swamped with a great quantity of written orders, instructions, routines, etc., issued by different persons, sometimes contradictory, often changed, and not in accordance with any uniform or well-considered system. Under these conditions, it is no wonder if officials or foremen hesitate before looking through their mass of papers whenever any unfamiliar situation arises.

Features of the Plan

The principal features of this plan are as follows:

1 The preparation of the standard instructions. This work should be delegated to one or more persons who are in a position to issue these instructions covering certain phases of shop work, such as the head of the Planning Department in preparing standard instructions as to how certain forms should be made out by the factory foremen in order to give the proper information that is needed by the Planning Department. The head of the Experimental Department might be delegated to prepare standard instructions covering the design of any particular part of the product. The writing of these instructions will also be to a con-

siderable extent part of the work of the General Manager. Regardless of who issues these standard instructions they should be O.K.'d and signed by the General Manager before they are sent out.

2 These instructions should be prepared on standard size sheets with headings showing the subjects, the instruction number, and the date of issue.

3 A system of classified subjects should be outlined under which all instructions should come.

4 No details of any importance should be omitted when writing up these instructions and they should be kept strictly up to date by revision and additions.

5 The standard instruction book should be kept in some particular place in each official's or foreman's desk where it will always be handy for reference and easily found when new instructions are to be inserted. This instruction book should be some suitable form of the loose-leaf type so that instructions may be easily inserted and kept under their proper heading.

6 The actual issuance and insertion in the various departmental books should be executed by one individual only, acting under direct authority of the General Manager.

7 Whenever a general instruction is issued which supersedes another, it should be titled—General Instruction (No.) Superseding Instruction (No.), and across the face of the first page of the instruction superseded there should be written in ink by the person inserting the new instruction—Superseded by Instruction (No.) on (Date). (Name)......................

8 At the bottom of each instruction should be the name of the officer or department to which the same instruction has been issued. This will enable the executive to know whether or not he may count on any other department head being familiar with its contents. Only such instructions as concern a particular department should be placed in a department instruction book. However, the general manager's instruction book should contain a copy of each instruction issued, filed by departments.

Classification of Subjects Under Which All Instructions Should Be Issued[1]

A = Policy
B = Rules and Regulations

1 These will be different for each contract.

C = Hiring, Handling, Training, and Discharging Men
D = Design and Standardization of products
E = Inspection
F = Organization
G = Preparation and Operation of Forms
H = Machines, Tools, and their Maintenance
J = Maintenance General
K = Motion, Time Study and Rate Setting
L = Drawing and Blue Prints
M = Receiving, Storing, Issuing, and Packing.

When any instructions are sent out they should be taken to the various departments to which they have been issued and inserted in the proper place in the instruction book. This must be done by the person who delivers the instructions and not left to the foreman. After the instruction has been placed in the book the foreman must be notified and his signature secured by having him place his initials after the notation of his department on the general manager's copy of the instruction. This will show that the instruction has been properly delivered and help to create a greater sense of responsibility on the part of the foreman for seeing that its provisions are carried out. Anyone who has signed a receipt for an instruction is strictly responsible thereafter if he fails to comply with the instructions therein. Experience has shown that no part of this plan is impractical. The business which has all its departments written up in this way possesses a record describing the procedure to be followed on every kind of routine work. Furthermore, the scheme of classification and indexing makes it possible to find at once any desired information.

Such instructions as these greatly simplify the task of breaking in new men. The time and expense which is consumed in their writing and issuing is regained many times over for they do away with the vast amount of wasted effort spent in giving special directions and in doing things wrong.

The following is a typical illustration of a general instruction, as actually used on a contract:

STANDARD INSTRUCTION 338-302
PURCHASE REQUISITIONS

General Instructions M-2

The purchase requisition form No. 9 has been des'

the purpose of avoiding verbal requests to the Purchasing Department. The purchase requisition when properly made out by those having authority to issue same will constitute an order on the Purchasing Department to purchase the material called for on the requisition. Under the heading Quantity must be given the quantity of the material desired. The size, kind, and name of the article must also appear on the requisition. In the space headed Reason must be given the reason for requesting the Purchasing Department to purchase the material called for. The name of the person making out the requisition must also be given. The foremen will not be allowed to make any purchases except through the Purchasing Department. The copy below shows a purchase requisition properly made out.

	Date		
Mat. Reg. No. 105			
PURCHASE REQUISITION	Mo.	Da.	Yr.
Purchase Ord. No. 86	5	1	19

Quantity	Size or Kind	Article	Vendor
1 gross	1½″–10	Flat head Bright Wood Screws	

Reason— For building rack for Wire Pipe Order No. 365	Classified Material	
	Unclassified Material	√

Signed: John Smith 5/1/19 Dept. Head	Checked P. D.	Appr'd Supt.

Form 9. Designed by Cooley & Marvin Co., Boston-Chicago-Toronto

Copies to:
Yard and Kilns
Cutting, Planing, Gluing, and Shaping

Bending
Veneering
Machining
Sanding
Assembly
Finishing
Upholstering
Shaped Stockman
Machined Stockman.

With the creation of the functional organization under way, we next study the product of the plant with a view toward its standardization and symbolization.

CHAPTER III

PRODUCT

THE average woodworking manufacturer considers that he must have a wide range of product in order to maintain his sales. A chair manufacturer, for instance, will manufacture practically every kind of chair, reasoning that while he may lose money on the rockers he makes, his large profitable line of diners would be cut into if he did not manufacture the rockers, as he would lose certain customers if he could not sell them both types. This line of reasoning is pursued until we find a factory of perhaps a hundred men manufacturing every type and kind of chair made, on many lines of which the manufacturer is losing money through the small volume produced.

Not only is part of the product manufactured at a direct loss, but the necessity of manufacturing so many lines also requires a considerably greater investment in equipment than would be necessary for a specialized line, inasmuch as some special equipment for each of the various lines must be maintained. Furthermore, the workmen of necessity must be changed from operation to operation to handle the various types of product with a resulting lowering of efficiency of operation. It is not maintained that a furniture manufacturer should make but one article or grade of article only, but for a chair manufacturer to make practically every type of chair known from cheap three-spindle kitchen chairs to expensive upholstered drawing-room chairs, or for a table manufacturer to try to manufacture a range of tables from the cheap variety turned out by automatic machinery and packed six in a crate, to expensive cabinet-made library tables, is absolutely inimicable to economy of operation. A chair manufacturer, for instance, should specialize in two or three lines, for to attempt to manufacture in a small plant, diners, rockers, office chairs, juvenile chairs, and bedroom chairs requires too great an

investment in equipment, and renders practically impossible any standardization of operating conditions or equipment.

As an example that such practice is not uncommon, the catalogue of a chair plant with but two hundred employees in all, displays six hundred and seventy-two numbers divided in the following classes:

Short-post wood-seat diners
Long-post wood-seat diners
Box-seat diners and arm chairs
Short-post wood-seat sewing rockers
Long-post wood-seat sewing rockers
Bedroom chairs and rockers
White enamel chairs, rockers, benches, and stools
Wood, cobbler, and pad-seat arm rockers
Spring seat-arm rockers
Typewriter chairs
Rotary office chairs and arm chairs
Stools
Children's high chairs
Youth's chairs and combination high chairs
Kindergarten and nursery chairs
Children's rockers
Misses' rockers
Douglas office chairs
Students' and lunchroom chairs
Boston rockers
Invalid chairs
Cribs
Folding chairs.

Standardization of Parts

Not only are the lines too extensive, but in the majority of woodworking factories but little attention is paid to the possibility of utilizing standard or interchangeable parts. Too often it is the practice of the designer in making up a new article to absolutely disregard the existence of parts very similar to those utilized in previous models. For instance, in a chair plant we found the following nineteen cross-sectional dimensions (in inches) of square stretchers:

⅝×¾	⅞×1¼
11/16×13/16	⅞×1½
¾×⅞	1×⅞
¾×1	1×1
¾×1⅛	1×1⅛
¾×15/16	1×1¼
¾×1½	1×1⅜
¾×2	1×1½
13/16×15/16	1×2

1×2 3/16

After working with the designer it was found that without injuring the beauty or utility of the designs in the least these nineteen cross-sections could be reduced to the following six:

⅝×¾	1×1
¾×1	1×1½
¾×1½	1×2

Examining the length of the above stretchers we found that they were being cut into the following lengths—10, 11½, 12½, 13, 14, 15, 16, 17, 18, 19, 20, 21, 21½, 22, 22½, 23, 42, and 43 inches. Standardization of these lengths showed that the large majority of such stretchers could be cut in sub-divisions of 42 inches, that is, 10½, 14, 21, and 42 inches. This allowed stock to be cut 42 inches long and re-sawed into halves, thirds or quarters. Where slight variations of these lengths were required an attachment was designed which took care of this at the chucking operation.

Next investigating the turned stretchers we found that ⅝ inch stretcher stock was being cut into the following lengths—9½, 10⅝, 11, 11¼, 11⅜, 11½, 11¾, 12, 12¼, 12⅝, 12¾, 12⅞, 13, 13⅛, 13¼, 13⅜, 13½, 13⅝, 13¾, 13⅞, 14, 14⅛, 14¼, 14⅜, 14½, 14¾, 14⅞, 15, 15⅜, 16⅛, 16½, 17, and 19½ inches. These lengths were similarly classified as were the square stretchers above.

Similarly, other parts may be so classified. For instance, the back posts of chairs are often carried in thirty or forty different sizes and perhaps eight or ten different angles of bend. We have frequently found this number in small chair factories of two hundred people. Standardization of this part alone, however, in a large plant employing six hundred people, reduced

the lumber size of all back posts to three units with a maximum of two different angles of bend. Inasmuch as the average chair post is 42 inches long and has a cross-section of at least 1 by 2¼ inches, the saving in material and machine labor can readily be realized for such standardization.

In case-goods factories, standardization of veneered panels is also a very important item. In one plant that was carrying over six hundred sizes of panels in stock, standardization of design eliminated all but fifty-three of these sizes. This enabled a great deal of the cutting to be done on gang-saws with chain-feeds owing to the larger sized orders of the fewer sizes.

Utilization of Waste

A fallacious argument used by many manufacturers when standardization of their line is suggested, is that a wide range of sizes allows them to utilize their waste to better advantage. For instance, in the making of square stretchers in a chair factory many manufacturers believe that they can make these more cheaply from the miscellaneous waste of the balance of the factory than they can cut them from new lumber. When one considers that there will be thousands of odd sizes of all kinds of lumber both dry and green which will have to be sorted out and then cut into the various sizes of stretchers, it is very evident (it has been demonstrated by the writer by actual experimentation and test) that it is far cheaper to cut stretcher stock directly from new lumber after proper standardization of cross-section and length as indicated above has been carried out, than to endeavor to put miscellaneous waste into such stock. To utilize the miscellaneous waste, aside from the cutting of a few small items such as corner blocks, cleats, braces, etc., it is recommended that a small by-product article be made such as tent-pins, pegs, tool-handles, etc., into which all types of waste, green or dry, and of any kind of wood may be put, such manufacture being carried out on automatic gang-saws and automatic turning or shaping machines. The handling of miscellaneous waste in any other manner than by automatic or semi-automatic machinery, will be found to cost more for labor than the reclamation of the material warrants.

Nomenclature of the Product

Unclassified as are the parts, the names of t

are often entirely based upon arbitrary numerals, as is almost invariably the case in referring to the parts themselves. For example, it is very common to find the various items of product catalogued as—5380-¼-AW, 580-½-L, 5097-AW, 4297-AWD, etc. These letters and figures have often very little significance. In place of such hit or miss nomenclature, it has been our custom to establish some such plan as follows:

Tables. In a table plant the following nomenclature was established for the product:

First digit indicates Class:—
1 Tabourettes
2 Pedestals
3 Printed Parlor Tables
4 Solid Parlor Tables
5 Printed Library Tables
6 Solid Library Tables
etc.

Second digit indicates Style:
1 Mission
2 Adam
3 William & Mary
4 Jacobean
5 French
etc.

Third and additional digits indicate individual pieces numbered serially in each class, and style as tables are brought out, thus:
643 The third Jacobean library table brought out
1178 The seventy-eighth Mission tabourette brought out.

Chairs. Chairs may be symbolized as follows:
First letter indicates Class of Chair
Second letter indicates Division of Class
Third letter indicates Detail of Finish
Numbers indicate Serial denoting particular chair in order brought out.

Short-post wood-seat diners . . . . DS
Long-post wood-seat diners . . . . DL
Box-seat diners . . . . DU
Box-seat arm diners . . . . DAU

Slip-seat diners .... DSU
Slip-seat arm diners .... DSAU
Short-post wood-seat sewing rockers .... RS
Long-post wood-seat sewing rockers.......... RL
Bedroom chairs .... B
Bedroom rockers (if finished white or ivory,
use W or I after symbol)................ BR
Wood seat-arm rockers .... R
Cobbler-seat arm rockers .... RC
Pad-seat arm rockers .... RP
Spring (auto) seat arm rockers .... RA
Typewriter chairs .... T
Rotary office chairs .... OR
Rotary office chairs upholstered .... ORU
Stools .... S
High chairs .... H
Combination high chairs .... HC
Youth's chairs (misses) .... Y
Youth's rockers (misses) .... YR
Kindergarten chairs .... K
Nursery chairs .... N
Douglas office chairs .... OD
Student's or lunchroom chairs L
Boston rockers .... RB
Invalid chairs I
Folding chairs .... F
Cribs (no symbol) ....Number only.

Nomenclature of Parts

Another difficulty encountered in establishing any nomenclature is the fact that the various parts of furniture are given different nomenclatures in different parts of the country. Figures 5 and 6 illustrate this fact by showing the different names given to the same part of a chair in different parts of the country. It will be well for the reader to familiarize himself somewhat with the various names of the chair parts as shown in these figures, as frequent references will be made to them, as the chair industry represents a large bulk of the woodworking industry. For instance, the following variation of names is found:

Front post or leg
Back or top slat

Centre or bottom slat
Runner or rocker

The terms stretcher, round, and spindle are very variously defined and used by different chair manufacturers. However, the most embarrassing phase in establishing standard nomenclature of parts, is found in the usual practice of assigning to a part the

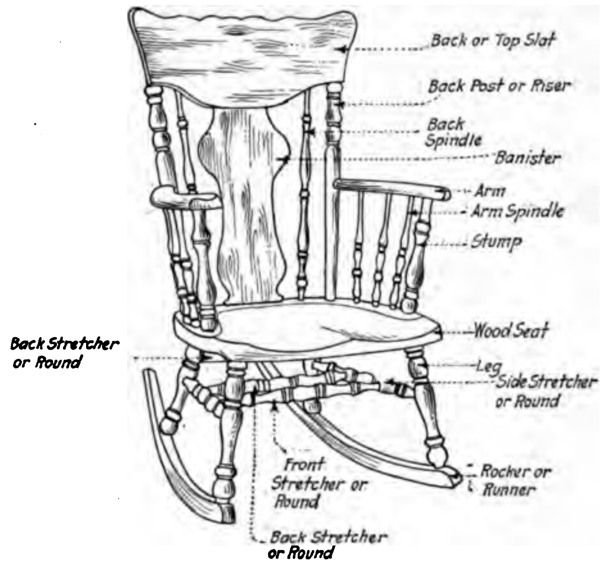


FIGURE 5.—A Rocking Chair With the Names of the Parts Indicated

number of the unit of product in which it is first used. For instance, in an analysis of product of a certain chair plant, it was found that the front post No. 5080 was used in the following chairs:

5097AW	4952AW
5095AW	5380 ¼ AW
5091AW	5380AW
5083AW	5080L
5038SW	5080 ½ L
4297AW	5093AW
4297AWB	4942 ½ L

It must be admitted that the operatives often become very familiar with these names and experience no considerable dif-

ficulty, but the utter lack of systematic nomenclature makes it very difficult for any one not familiar with the plant and product to comprehend the names of the various parts or to assign them to the proper units of product. In place of such arbitrary numbers, a simple form of mnemonic symbolization for each part, followed by serial numerals indicating the individual parts under that classification, is found much more preferable.

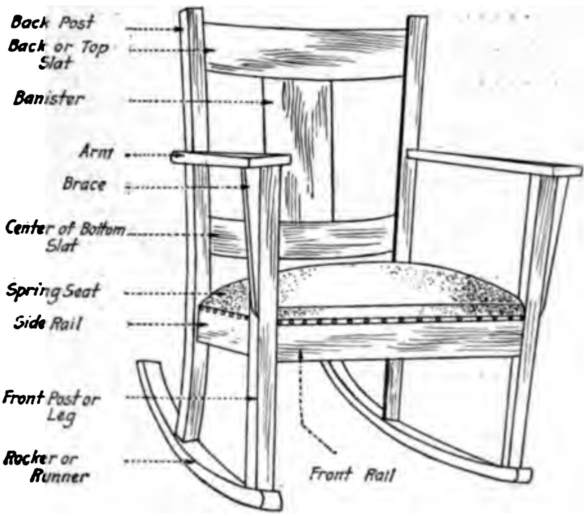


FIGURE 6.—Another Style of Chair With the Names of the Parts Indicated

For chairs the following has been found very satisfactory:

Bent Back	BxB
Straight Back	BxS
Bent Banister	BnB
Straight Banister	BnS
Bent Center	CnB
Straight Center	CnS.
Square Back Post	PBX
Turned Back Post	PBT
Square Front Post	PFX
Turned Front Post	PFT
Front Rail	RF
Side Rail	RS
Back Rail	RB
Square Spindle	

Turned Spindle	SpT
Square Stretcher	StX
Turned Stretcher	StT
Square Pillar	PlX
Turned Pillar	PlT
Rocker	Rk
Rizer Back	RzB
Rizer Side	RzS
Arm	Am
Apron	Ap
Bow	Bw
Wood Seat	SW
Frame Seat	SF
Box Seat	SB
Square Stump	SmX
Turned Stump	SmT
Special	Z
Corner Block	CB
Rim	Rm
Brace	Br

In a table factory the following was found satisfactory:

Base Blocks	
Solid	BBS
Built-up	BBB
Base Ends	
Solid	BES
Veneered	BEV
Brackets	
Shelf	BrS
Leg	BrL
Cleats	Cl
Cleat Blocks	ClB
Columns	
Solid	CS
Built-up	CB
Corner Blocks	CrBl
Crosses	Cr
Desk	
Backs	DkB
Brackets	DkBr

- Caps .... DkC
- Front Pieces .... DkF
- Ink-well Holders .... DkI
- Lids .... DkL
- Shelves .... DkS
- Slats .... DkSl
- Tops .... DkT

Drawer

- Backs .... DBx
- Bottoms .... DB
- Sides .... DS
- Slides .... DSl
- Stops .... DSt
- Tops .... DT

Feet

- Solid .... FS
- Veneered .... FV

Legs

- Built-up .... LB
- Built-up Veneer .... LBV
- Solid .... LS
- Turned .... LT
- Veneered LV

Leg Blocks .... LBl

Leg Plugs

- Solid .... LP
- Slotted .... LPS

Moulding

- Top .... MT
- Shelf Side .... MSS
- Shelf End .... MSE
- Shelf Rail .... MR

Oval Drawer Fronts

- Solid .... ODS
- Veneered .... ODV

Panels

- Solid .... PS
- Veneered .... PV

Rails

- Back .... RB
- Corner .... RC
- Front ....

Oval .... RO
Side .... RS
Shelves
Book .... SB
Solid .... SS
Spread .... SP
Veneered .... SV
Specials .... Z
Styles .... Sy
Tenons .... Tn
Tops
Solid .... TS
Veneered .... TV

Having now covered the organization and classified and symbolized the product, we will turn to the principal item of material used in woodworking, that is, lumber.

CHAPTER IV

LUMBER

One of the factors which is as unstandardized as any other in the woodworking industry, is the selection of the proper grade of lumber. Some manufacturers maintain that it is cheaper to buy "log run" while others will buy nothing but "number one common." To a large extent, it is believed that this is a problem which can only be solved locally by intelligent investigation and test. In making such a test every influencing factor must be studied and recorded. For instance, first determine the price per thousand board feet delivered at the factory including freight, handling, etc. Finally, against this must be checked the resulting usable portion found by calculating the board feet in the resulting finished product. These two simple calculations alone are not sufficient, however, as the effect on labor cost of handling the greater amount of waste through the factory must be calculated, that is, the additional holding up of inspectors in throwing out culls and the individual operating efficiency of each machine handling the product, particularly that of the cut-off and rip saws, where often twice as much material must be handled of log run than of number one common to give the same production. However, such a test is capable of being solved quite accurately if sufficient care is taken, and no manufacturer should feel justified in stating that a particular grade is most economical for his factory or product, until he has made such a detailed test over a sufficiently long period of time and with all grades in question. Unfortunately, in making such tests the effect of increased labor cost is very often ignored. In the majority of tests of this nature which we have carried out it has been found that higher grade lumber is usually cheaper in the end than log run, but as stated above a local test only can determine this.

Storage and Handling

A woodworking plant of comparatively small size will use at least 2,000,000 board feet of lumber per year. Considering that average hard wood weighs 4 pounds per board foot, this means that in such a small factory 4000 tons of lumber a year must be handled. Furthermore, lumber is a rough bulky article and because of its length, un- It is therefore evident

that in the woodworking industry the handling of the lumber is a major problem and one which receives but little attention in the average factory. It has often been found possible to reduce the cost of handling lumber 75 per cent, through the application of the simple principles outlined below. In considering the handling of any heavy bulky material, the major proposition is to accomplish the handling of this material whenever possible by means of machinery or transportation devices, rather than by human power, and this applies to lumber very noticeably.

Figure 7 illustrates the usual method of handling lumber in a woodworking plant. From the railroad car it is piled onto a dead pile, being scaled as it is removed from the car. The

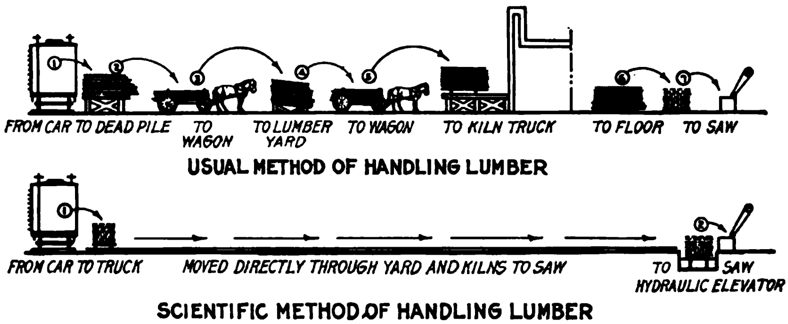


FIGURE 7.—Comparison of Usual and Scientific Method of Handling Lumber

dead pile is then sorted into special lengths, widths, or grades, if this is the practice in the local plant, although often such sorting is not carried out until the lumber is to be taken into the factory. From the dead pile the lumber is next piled onto a wagon and again repiled in the lumber yard. When it is to be taken to the factory, it is again piled onto the wagon, from which it is piled onto a kiln truck. In some plants the kiln truck is run directly into the factory, while in others still another transportation by means of a wagon is required. Finally, the lumber is piled down onto the floor of the factory near the saws, from which the workmen must pick it up board by board and place it on the saw bed. As indicated in Figure 7, the scientific method of handling is that after once being removed from the railroad car, aside from moving a car about the industrial trackage, the lumber is not again handled until it is thrown by the sawyer onto the bench of his saw, the pile being maintained at the proper

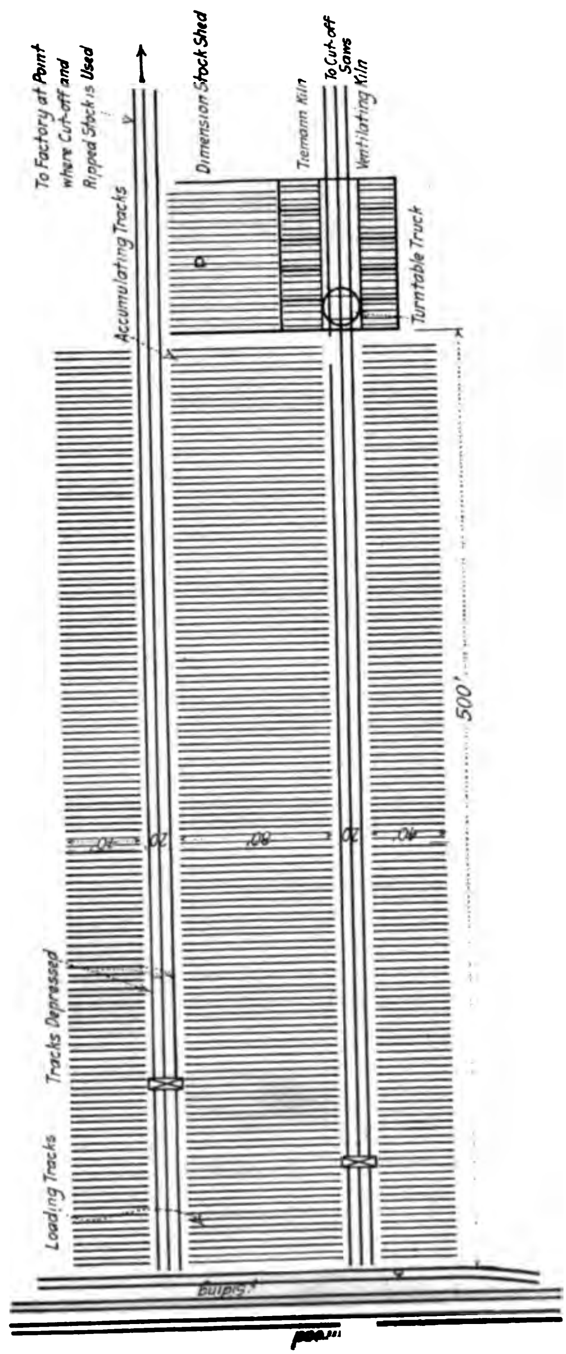


FIGURE 8.—Layout of a Model Lumber Yard

height constantly by an elevator. In other words, instead of six or seven repilings, but one is used in this method. It is this elimination of repiling which allows the saving of 75 per cent in cost of lumber handling to be realized.

Layout of Lumber Yard

Figure 8 shows the layout of a model lumber yard, holding 2,000,000 board feet. The lumber is received in railroad cars on the railroad siding *A*. The yard is equipped throughout with industrial tracking set at 42 inch gauge, the usual weight of rail being 16 pounds per yard. On the loading track *B* small trucks or lumber sections are placed, such as are shown in Figures 9 or 10. Across two such sections a heavy piece of timber is placed and lengthwise between two such sections of two trucks each, the lumber is piled in loads of about 4000 board feet; that is, assuming 16 to 18 feet as the average length of the lumber, piled 6 feet wide and 8 feet high, the cars will hold about 4000 board feet. As the lumber is removed from the car, it is not only scaled, but sorted as each board is removed and piled on various cars such as that just outlined, which are placed along the loading track *B*. When a car is filled, it is moved along either of the transfer tracks *C*1 or *C*2 on a transfer car. These transfer tracks are depressed so that the small cars of lumber may run onto the transfer cars directly, from which they are shunted off onto any section of the track desired. The entire track system is slightly inclined toward the factory. This is to utilize the force of gravity in moving the heavy cars. As a truck is placed in its definite location within the yard, it is covered with a light roofing of cheap boards to prevent the deteriorating effect of rain, and the proper notice sent to the Planning Department as described on page 49 under the heading lumber control.

Dimension stock is handled in the same way, except that it is pushed into the dimension stock shed *D* which is tracked similarly to the yard proper. When a load is to be pushed into the dry kilns it is pushed along the transfer track *C*1, and is received on the turntable car *E* within the kiln building, from which it may be pushed directly into a kiln pocket. When the lumber has been dried, it is again received on turntable *E* and pushed directly to the cut-off saws in the factory. Transfer track *C*2 is so arranged, that dimension stock may be received on the transfer car directly from the dimension stock shed *D* and pushed directly

to that point in the factory, where cut and ripped stock normally arrives from process. In other words, all cut and ripped stock, whether from lumber or from dimension stock, is delivered directly to the one proper point in the factory.

The physical layout and equipment of the yard, however, is not the only factor necessary towards the economical handling of lumber. It is also necessary by means of motion and time study to create operating standards which will serve as a basis for the

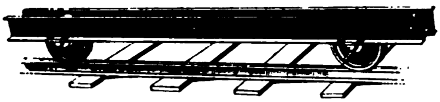


FIGURE 9.—Truck for Use in a Lumber Yard

utilization of a wage incentive to force the workmen to maintain the necessary high standard of production. The following time study and bonus rate represents such a study made at a woodworking plant for unloading of lumber from cars. Similar

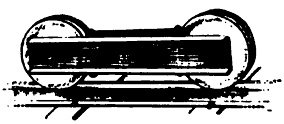


FIGURE 10.—Another Type of Lumber Truck

rates can be worked out for other functions of handling lumber, an example of which appeared in an article by the author in the August, 1918, issue of *Industrial Management.*

BONUS RATE FOR UNLOADING LUMBER IN BOARD FORM FROM CARS

Rate Symbol

L-1	All 1 inch lumber, except gum and resawed birch
L-2	All 1¼ inch lumber
L-3	All 1½ inch lumber and 1 inch gum
L-4	All 1¾ inch lumber
L-5	All 2 inch lumber
L-6	All 2½ inch lumber
L-7	All 3 inch lumber
L-8	All 1 inch resawed birch

Time Allowed

L-1	3.82 minutes	=	0.064 hour	per 100 board feet
L-2	2.84	=	0.047	
L-3	2.37	=	0.040	
L-4	2.15	=	0.036	
L-5	1.80	=	0.03	
L-6	1.28	=	0.021	
L-7	1.17	=	0.02	
L-8	4.13	=	0.069	

Work Handled Under This Rate

These rates include the unloading of the above mentioned classes of lumber from cars placed at predetermined spots and piling same onto cars.

Description of Present Conditions and Cost

The operation as at present performed consists of one man inside the car handing out the lumber to a man on the outside who receives and piles it.

Past records, although somewhat inaccurate, show that 124,305 board feet of 1 inch lumber were unloaded in 142 hours, which averages 875 board feet per hour, or 6.85 minutes per 100 board feet. This would total 8750 board feet unloaded per 10-hour day by two men at a labor cost of $5.00 or at the rate of $0.57 per 1000 board feet.

Lumber records also show that 33,891 board feet of 1¼ inch lumber were unloaded in 23 hours, or at a rate of 14,700 board feet per 10-hour day. This would cost $5.00 per day for labor or at the rate of $0.34 per 1000 board feet.

Past records also show 38,930 board feet of lumber classed under L-3 were unloaded in 32.5 hours, or at a rate of 12,000 board feet per 10-hour day, which would cost $5.00 for labor, or at the rate of $0.416 per 1000 board feet.

Other records show that 63,095 board feet of 1¾ inch lumber were unloaded by two men in 70 hours, or 905 board feet per hour, which would equal 6.64 minutes per 100 board feet. This would be a total of 9050 board feet per 10-hour day at a labor cost of $5.00, or at the rate of $0.553 per 1000 board feet.

Recommendations for Standardization of Conditions and Cost

This operation will be performed under the bonus system in the same manner as at present.

At 95 per cent efficiency a man would make $0.275 per hour, as a base rate, plus 20 per cent bonus or $0.33 per hour per man, which would equal $0.66 per hour for two men. The cost at 95 per cent efficiency and the resulting savings are shown in Table 1.

TABLE 1—COST OF UNLOADING LUMBER IN BOARD FORM

Class	Present Cost in Dollars	Cost at 95% Efficiency	Saving	
			Dollars	Per Cent
	Per 1000 Board Feet			
L-1	0.57	0.42	0.15	26.4
L-2	0.34	0.312	0.028	9.0
L-3	0.41	0.262	0.148	36.0
L-4	0.55	0.236	0.314	56.0
L-5	No record	0.198	....	....
L-6	No record	0.141	....	....
L-7	No record	0.129	....	....

Furthermore all demurrage on unloading lumber will be avoided if the Planning Department properly outlines the work.

TABLE 2—DATA FOR UNLOADING LUMBER IN BOARD FORM

Approximately 15,000 board feet per car

Class	Lumber	Board Feet per Board	Weight per Board, Lb.	Average Number of Boards per Car
L-1	All 1 in. except gum and resawed birch	6.5	26	2300
L-2	All 1¼ in.	9.5	38	1580
L-3	All 1½ in. and 1 in. gum	12.0	48	1250
L-4	All 1¾ in.	13.5	54	1110
L-5	All 2 in.	15.5	62	970
L-6	All 2½ in.	25.0	100	600
L-7	All 3 in.	28.0	112	540

Analysis:

A = Time required to lift board out of cars to man on outside = 0.20 minute;

B = Time required for opening and getting into car = 5 minutes;
C = Time required leaving car = 1.15 minutes;
D = Time required punching time card = 2.0 minutes.

As actual handling of board occupies 85 per cent of time, 85 per cent of theoretical allowance must be made for rest and delays.

As shown on Figure 11 the size of the lumber has little effect on the handling time per board as it is shown that the average handling time per board for 1 and 1¾ inch lumber varies but approximately 6 per cent, therefore time per board is the constant.

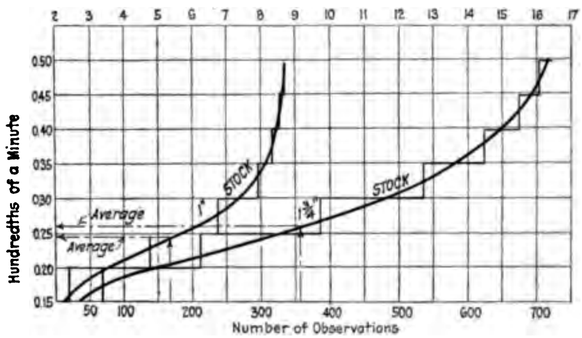


FIGURE 11.—Chart Showing Handling Time per Board

Synthesis:

T = Time allowed per 100 board feet,
t = Actual time per 100 board feet.

L-1

$\frac{100}{6.5} = 15.4$ = number of boards per 100 board feet.

$15.4 \times A = 15.4 \times 0.20$ minute $= 3.08$ minutes = handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066$ = car per 100 board feet.

Therefore $0.0066\ (B+C+D) = 0.054$ minute = allowance per 100 board feet for opening door, etc. $= y$.

$t = x + y = 3.08 + 0.054 = 3.134$ minutes;
z = per cent allowance for rest and delays = 22 (load = 26 pounds which require 28 per cent rest time under strain = 85 per cent, therefore allow 22 per cent);

$T = 1 . z(t) = 1.22\ (3.134) = 3.82$ minutes per 100 board feet.

L–2

$\frac{100}{9.5} = 10.53$ = number of boards per 100 board feet.

$10.53 \times A = 10.53 \times 0.20$ minute $= 2.106$ minutes = handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066$ = car per 100 board feet.

Therefore $0.0066\ (B+C+D) = 0.054$ minute = allowance per 100 board feet for opening door, etc. $= y$.

$t = x + y = 2.106 + 0.054 = 2.16$ minutes.

z = per cent allowance for rest and delays $= 31.5$.

$T = 1 . z(t) = 1.315\ (2.16) = 2.84$ minutes per 100 board feet.

L–3

$\frac{100}{12} = 8.33$ = number of boards per 100 board feet.

$8.33 \times A = 8.33 \times 0.20$ minute $= 1.66$ minutes = handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066$ = car per 100 board feet.

Therefore $0.0066\ (B+C+D) = 0.054$ minute = allowance per 100 board feet for opening door, etc. $= y$.

$t = x + y = 0.66 + 0.054 = 1.72$ minutes;

z = per cent allowance for rest and delays $= 37.4$;

$T = 1 . z(t) = 1.374\ (1.72) = 2.37$ minutes per 100 board feet.

L–4

$\frac{100}{13.5} = 7.41$ = number of boards per 100 board feet.

$7.41 \times A = 7.41 \times 0.20$ minute $= 1.482$ minutes = handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066$ = car per 100 board feet.

Therefore $0.0066\ (B+C+D) = 0.054$ minute = allowance per 100 board feet for opening door, etc. $= y$.

$t = x + y = 0.482 + 0.054 = 1.54$ minutes;

z = per cent allowance for rest and delays $= 39$.

$T = 1 . z(t) = 1.39\ (1.54) = 2.15$ minutes per 100 board feet.

L–5

$\frac{100}{15.5} = 6.045$ = number of boards per 100 board feet.

$6.045 \times A = 6.045 \times 0.20$ minute $= 1.209$ minutes $=$ handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066 =$ car per 100 board feet.

Therefore $0.0066\ (B+C+D) = 0.054$ minute $=$ allowance per 100 board feet for opening door, etc. $= y$.

$t = x + y = 1.209 + 0.054 = 1.26$ minutes;

$z =$ per cent allowance for rest and delays $= 42.5$ per cent;

$T = 1 . z(t) = 1.425\ (1.26) = 1.80$ minutes per 100 board feet.

L–6

$\frac{100}{25} = 4 =$ number of boards per 100 board feet.

$4 \times A = 4 \times 0.20$ minute $= 0.8$ minute $=$ handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066 =$ car per 100 board feet.

Therefore $0.0066\ (B+C+D) = 0.054$ minute allowance per 100 board feet for opening door, etc. $= y$.

$t = x + y = 0.8 + 0.054 = 8.54$ minutes;

$z =$ per cent allowance for rest and delays $= 50$ per cent;

$T = 1 . z(t) = 1.50(0.854) = 1.28$ minutes per 100 board feet.

L–7

$\frac{100}{28} = 3.57 =$ number of boards per 100 board feet.

$3.57 \times A = 3.57 \times 0.20$ minute $= 0.714$ minute $=$ handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066 =$ car per 100 board feet.

Therefore $0.0066\ (B+C+D) = 0.054$ minute $=$ allowance per 100 board feet for opening door, etc. $= y$.

$t = x + y = 0.714 + 0.054 = 0.77$ minute;

$z =$ per cent allowance for rest and delays $= 52$;

$T = 1 . z(t) = 1.52\ (0.77) = 1.17$ minutes per 100 board feet.

L–8

Resawed Birch. Average 6 board feet per board.

$\frac{100}{6} = 16.66 =$ number of boards per 100 board feet.

$16.66 \times A = 16.66 \times 0.20$ minute $= 3.33$ minutes $=$ handling time for 100 board feet $= x$.

$\frac{100}{15{,}000} = 0.0066 =$ car per 100 board feet.

Therefore $0.0066\ (B+C+D)=0.054$ minute = allowance per 100 board feet for opening door, etc. $=y$.

$t=x+y=3.33+0.054=3.384$ minutes;

z = per cent allowance for rest and delays = 20.

$T=1.z(t)=1.22\ (3.384)=4.13$ minutes = 0.069 hour per 100 board feet.

Bonus

Labor rate \$0.25 per hour.

Base rate \$0.275 per hour.

Pay bonus based on curve shown in Figure 116 (see page 222).

When lumber invoices are received by Planning Department, they will decide when cars will be unloaded. They will make out time cards showing number of board feet and time in which to be handled. Workmen will stamp cards at start and finish of job.

Drying Lumber

The major consideration in the handling of lumber in the furniture industry is the proper drying of the lumber. This drying presents two principal factors; first, the lumber must be so dried that good furniture can be made from it, and second, the process of drying itself must not waste the lumber and must economically utilize the necessary heat. This subject of drying is as unstandardized throughout the industry as is any other factor. Several volumes could be written covering all the various theories of drying lumber and types of drying apparatus in use throughout the country at the present time. The war has had a salutary effect upon this situation, however, in that the Bureau of Forestry and the University of Wisconsin have carried on some valuable experiments in the drying of lumber. These experiments were primarily intended to investigate the possibilities of quick-drying spruce for aeroplane purposes, but they have led to the development of the Tiemann Kiln named after its inventor, H. D. Tiemann, who is in charge of the Section of Timber Physics and Kiln Drying Experiments of the U. S. Forest Service. These experiments were carried out in a highly scientific manner and if the findings are only recognized and applied by the furniture industry, tremendous improvements in this process will result.

The theory of drying is to decrease weight, increase strength, and primarily to prevent shrinkage of the wood after manufacturing. Aside from moisture existing from external causes such as rain lumber normally contains at what is known as the

saturation point" from 25 to 30 per cent of moisture. By air drying, that is, piling in yards for a period of from six months to a year, this moisture may be reduced to a total of from 8 to 18 per cent, although in the eastern states 14 per cent is possibly a fair average.

Air drying, however, warps, checks, case-hardens, and honeycombs lumber, with an average result of causing a loss of about 12 per cent in hard woods and 5 per cent in soft woods. Kiln drying, if properly carried on, considerably reduces these losses, greatly cuts down the manufacturing time and also makes the wood suitable for working. A certain amount of air drying varying from one to eight months is carried out by practically all plants, and in the kiln-drying process, lack of standardization is demonstrated by the fact that the kiln-drying process itself utilizes temperatures all the way from 60 to 300 degrees requiring from thirty-six hours to six weeks for 1-inch stock and from two to five months for thicker stock.* Also, in many plants, wood is steamed before kiln drying at from 20 to 40 pounds pressure per square inch for the purpose of eliminating water by the expansion of the air in the cellular structure of the wood.

Principles of Kiln Drying

The principles or requirements for the proper drying of lumber as stated by H. D. Tiemann in "The Kiln Drying of Lumber" are as follows:

1 The evaporation from the surface of a stick should not exceed the rate at which the moisture transfuses from the interior to the surface
2 Drying should proceed uniformly at all points, otherwise extra stresses are set up in the wood, causing warping
3 Heat should penetrate to the interior of the lumber before drying begins
4 The humidity should be suited to the condition of the wood at the start and reduced in the proper ratio as drying progresses. With wet or green wood it should usually be held uniform at a degree which will prevent the surface from drying below its fiber saturation point until all the free water has evaporated, then gradually reduced to remove the hygroscopic moisture.

5 The temperature should be uniform and as high as the species under treatment will stand without excessive shrinkage, collapse, or checking
6 Rate of drying should be controlled by the amount of humidity in the air and not by the rate of circulation, which should be made ample at all times
7 In drying the refractory hardwoods, such as oak, best results are obtained at a comparatively low temperature. In more easily dried hardwoods, such as maple, and some of the more difficult softwoods, as cypress, the process may be hastened by a higher temtemperature, but not one above the boiling point. In many of the softwoods the rate of drying may be very greatly increased by heating above the boiling point with a large circulation of vapor at atmospheric pressure. In this case the dewpoint should be maintained at 212 degrees Fahrenheit to prevent surface drying or casehardening
8 Unequal shrinkage between the exterior and interior portions of the boards and also unequal chemical changes must be guarded against by temperatures and humidities suited to the species in question to prevent subsequent cupping and warping.
9 The degree of dryness attained should conform to the use to which the wood is put
10 Proper piling of the lumber and weighting to prevent warping are of great importance

Type of Kilns

From a physical standpoint the two types of kilns used are the continuous and pocket types. The continuous or progressive kiln provides for the lumber being entered on cars running on tracks, one load behind the other at one end of the kiln, and gradually advanced through the kiln as each new load is put in, finally being pushed out the other end when completed. Except where large quantities of the same kind of wood are to be dried this plan is seldom feasible in the furniture industry. Furthermore, the presence of both green and dry lumber in the same kiln is objectionable, although sometimes the heating arrangement overcomes this objection.

The pocket type consists of small com[illegible]

one or more loads of the same kind of lumber are introduced at the same time and which remain stationary until time for removal. This allows, by the use of a number of such pockets, several kinds of lumber to be dried at once in the same kiln and is the more sucessful in drying lumber for furniture, especially in small plants.

The two major groups of kilns are dry air and moist air. For the drying of lumber, except in very obsolete plants, the dry-air

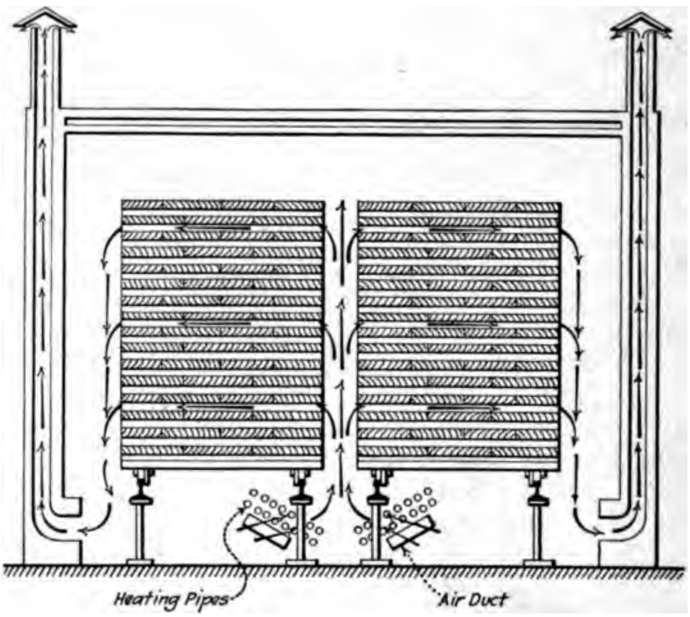


FIGURE 12.—Ventilated Type of Dry Kiln

method, which consists practically of a hot-air furnace, has entirely disappeared. In many furniture factories, however, it is still the policy to maintain such dry-air kilns, piling into them the cut or dimension stock, which practice is far from as efficient as that of drying the stock in the lumber form in a moist-air kiln, both from the standpoint of cost of handling the material and waste of lumber.

Moist-air kilns may be divided into two subdivisions, external circulation, and internal circulation. The external circulation is subdivided into the ventilated and forced-draft types and internal circulating kilns are divided into the condensing type and

the water spray or Tiemann type. In other words, kilns may be classified as follows:

Class 1 Dry Air
Class 2 Moist Air
- External Circulation
  - Ventilated
  - Forced Draft
- Internal Circulation
  - Condensing
  - Tiemann or Water Spray

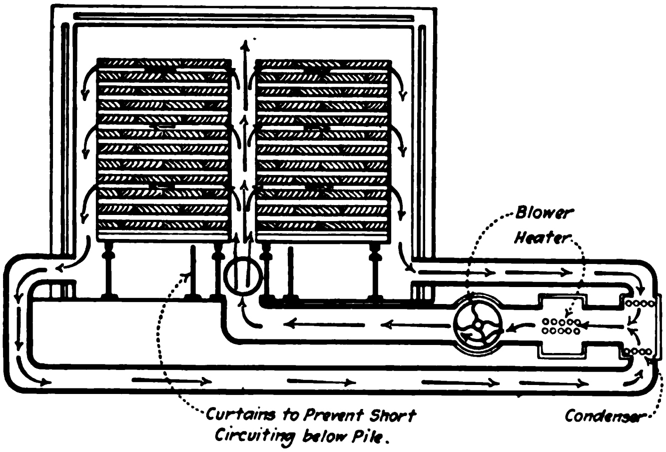


FIGURE 13.—Forced Draft Type of Dry Kiln

There are also the steam spray (a modification of the Tiemann type) and superheated kilns, neither of which, however, need be considered, as they are not common types.

Figure 12 illustrates the ventilated type. The fresh air enters through the air ducts beneath the heating pipes. The heated air, after passing through the heating pipes works through the lumber horizontally, taking up the moisture from the lumber, and as it becomes cooler and therefore heavier, sinks to the base of the kiln where it is sucked through openings into tall chimneys thus passing into the external atmosphere.

Figure 13 illustrates the forced-draft kiln. In this type the heating apparatus is ordinarily located without the kiln proper. Hot air is forced through the heating system into the kiln where it circulates similarly to the ventilated type, although the moisture in the cold air is usually removed as condensate rather than being passed off through chimneys.

Figure 14 illustrates the condensing type of kiln. The heating pipes are located beneath the lumber, and water-cooled condensing pipes along the sides of the kilns. The warm air which has passed through the heating pipes rises, passing through the lumber horizontally, absórbing moisture, and the cool damp air in falling to the bottom of the kiln has the water removed from it by means of the condensers. Steam sprays are often introduced into both the condensing and ventilated types to increase the humidity.

The Tiemann kiln is shown in Figure 15. It is of the internal

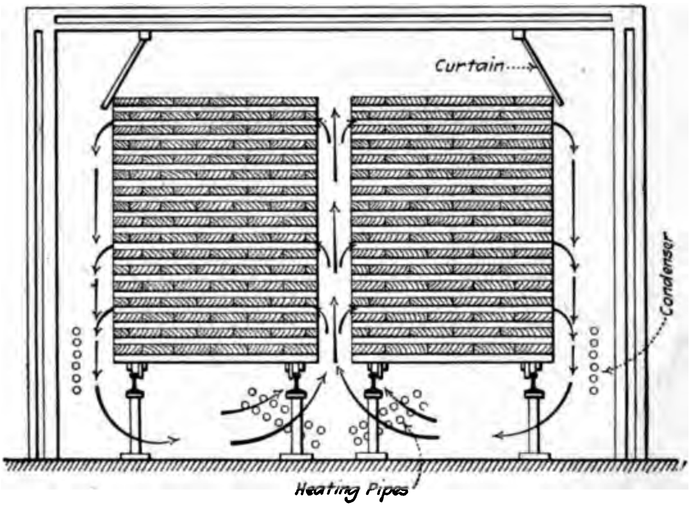


FIGURE 14.—Condensing Type of Dry Kiln

circulation type and so arranged that the humidity may be lowered as the temperature is increased thus maintaining an even drying stress on the lumber through all its stages while in the kiln.

The humidity is changed by saturating the air with water vapor at varying temperatures. For high humidity, hot water is used and for low, cold water. The temperature is raised by having the heating pipes arranged in several units so that the steam may be admitted to each unit separately.

There are located behind the kiln three water sumps and a pit in which a pump is located. One sump is used for cold water from the cold-water main, one for the warm water returning from the kiln and the other for hot water which is heated by means of a

coil of steam pipes placed in the sump. By regulating the valves in the pipes leading from the sumps to the pump, water of any temperature may be pumped out through the water spray and will come in contact with the air. By this arrangement it is possible to prevent case hardening and honeycombing so prevalent in other types of kilns and to lessen the time required for properly drying the lumber. If through mismanagement of the kiln case hardening should develop there is a steam spray provided that may be used to still further increase the humidity and thus over-

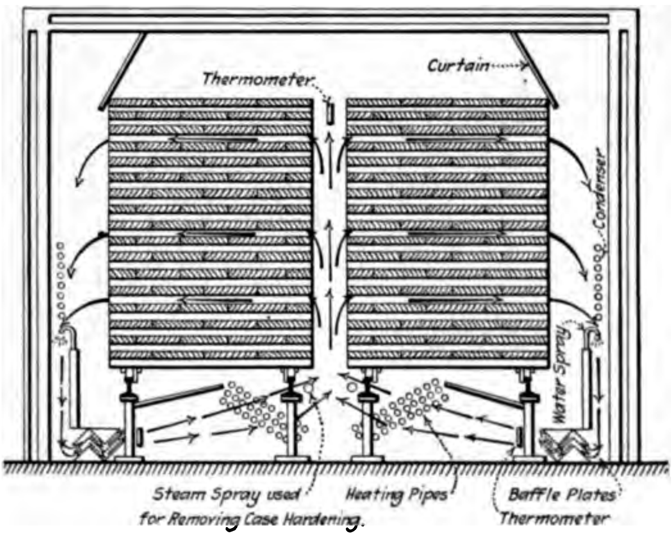


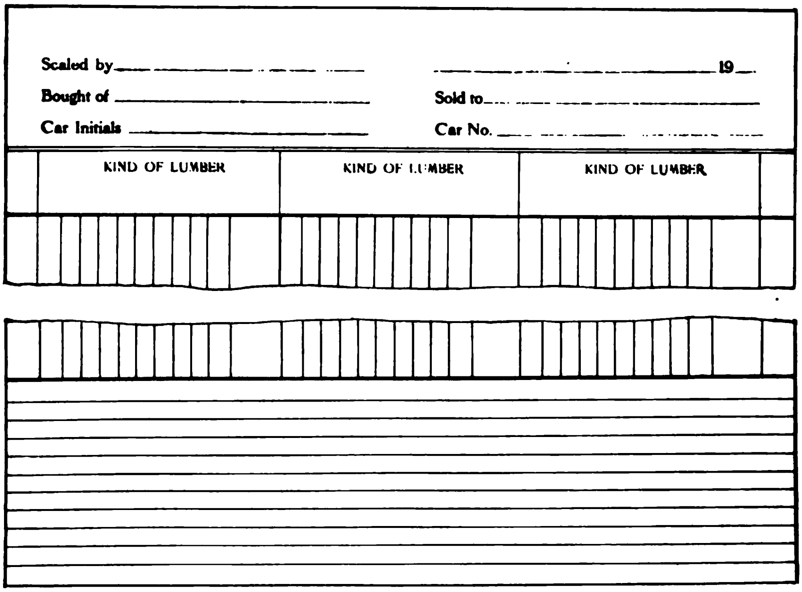
FIGURE 15.—Tiermann Type of Dry Kiln

come it, as case hardening is usually caused by using too high a temperature and too low a humidity.

After the load of lumber is placed in the kiln a hygrometer connected with a recording dial is placed on the top of the load. Through the recording dial a permanent record of the humidity maintained in the kiln at all times is available. There are also two recording thermometers placed in the kiln. One is placed in such a position that the temperature of the air before heating will be seen and the other placed near the top of the kilns giving the temperature of the heated air. Canvas curtains are placed in the position shown in Figure 15 so that "short circuiting" of the air above the load will

When starting the drying operation the valve in the pipe leading from the hot-water sump to the pump is opened and the hot water is pumped to the water spray where it comes in contact with the air, thus increasing its humidity.

The air then follows the course shown by the arrows in Figure 15 through the baffle plates. The baffle plates prevent any water passing through the heating pipes with the air. One heating unit on each side of the kiln is turned on and the air is heated passing



Scaled by __________ __________ 19__

Bought of __________ Sold to __________

Car Initials __________ Car No. __________

	KIND OF LUMBER	KIND OF LUMBER	KIND OF LUMBER	

FIGURE 16.—Sheet to Record Results of Scaling Lumber

on between the two loads as shown by the arrows. The heated air then works out through the spaces between the boards and comes in contact with the condenser which causes the moisture that the air has collected while passing through the lumber to drop down to the drain.

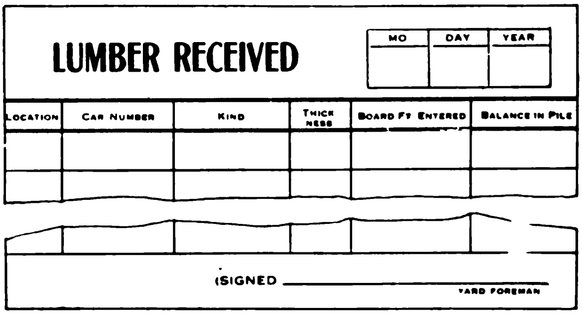
This circulation continues and the heat is gradually raised while the humidity is lowered in proportion until the percentage test shows the lumber to be of the required dryness.

The recording dial records are filed according to the kind of lumber and the original percentage of water in the lumber, thus serve as records of the temperature and humidity required to dry that kind of lumber most efficiently.

For use in the furniture industries, experimentation carried out by the author has indicated that the ventilating type of kiln shown in Figure 12 is the most suitable for drying birch, maple, and elm, while the Tiemann type is best adapted for drying oak and chestnut. It is frankly admitted that these experiments have not been carried to sufficient detail to definitely prove this point, but so far it has been indicated to the author that these two methods will dry the classes of woods designated in the most economical manner considering the resulting product.

Lumber Control

In a great many woodworking plants the control of lumber is handled in as indefinite fashion as is the selection of the grade



LUMBER RECEIVED

MO	DAY	YEAR

LOCATION	CAR NUMBER	KIND	THICKNESS	BOARD FT ENTERED	BALANCE IN PILE

(SIGNED ____________ YARD FOREMAN

Figure 17.—Form for Record of Lumber Received

to be used as outlined at the beginning of this chapter. The detail to which the control of the lumber should be carried depends, of course, upon the amount and quality handled. The following methods are especially designed for use in large plants or where very accurate information regarding lumber is required.

The first function upon receiving the lumber is its scaling or inspection, which is carried out according to specific definite rules formulated by the lumber associations. The results of this scaling are usually indicated on a sheet similar in design to that shown in Figure 16, and this serves as a basis for accepting or rejecting the lumber as billed. The final payment for the lumber is based upon findings as reported in this operation which is carried out by an experienced lumber scaler, as the lumber is removed board by board from the railroad cars. Any considerable portion of the lumber wh[illegible]ling to be below

standard is usually piled aside until the matter is settled with the vendor.

In a small factory the reception of this form in the Planning

DIMENSION STOCK RECEIVED

MO	DAY	YEAR

LOCATION	CAR NUMBER	KIND	SIZE			NO. ENTERED	BALANCE
			Length	Width	Thickness		

(SIGNED)____________________
RECORD CLERK.

FIGURE 18.—Form for Record of Dimension Stock Received

Department is considered as sufficient information for the maintenance of lumber receipt records. Where a detailed Planning Department is maintained, however, it is essential that the reception be further indicated on forms similar to Figures 17 and 18

LUMBER RECORD

LOCATION

Thickness____________________

Kind____________________

DATE			BD. FT. ENTERED OR WITHDRAWN	BOARD FEET BALANCE	CAR OR ORDER NO	HANDLED BY
MO	DAY	YR.				

FIGURE 19.—Form for Record Kept With Each Pile in the Lumber Yard

which indicate not only the lumber or dimension stock received, but also the location in which it is placed in the yard, with more or less description as to just what kind of lumber it is. For instance, high-grade lumber such as quartered oak is often sorted during the scaling into various widths which should be reported

to the Planning Department in order that when ordering lumber into the kilns or factory they may designate the proper width of board required. The purpose of this sorting into definite widths is to avoid waste. For instance, a part requiring lumber 6 inches wide if cut from 7 inch lumber results in an inch of waste. White and yellow birch are also usually separated. These sortings are physically controlled by piling the different varieties onto separate cars as the lumber is removed and scaled from the car, thus avoiding any rehandling or repiling.

The lumber yard should be laid out in symbolized sections, each pile having a symbol designating its location. On each pile, protected by a waterproof cover, is placed a record such as shown in Figure 19. It will be noted that this form is designed with

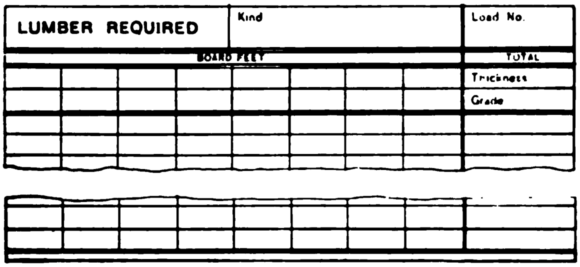


FIGURE 20.—Form for Planning Department Showing Lumber Required for Orders

extra large spacings for the purpose of allowing the entering of figures in the yard by the more or less large-fisted tally men. When the forms shown in Figures 17 or 18, the records of receipt, are received in the Planning Department, a perpetual inventory maintained in card form, is posted. To avoid multiplicity of forms, the form shown in Figure 19 which is used on the piles in the yard may be used in the Planning Department for maintenance of this inventory.

As outlined above we have now seen that all lumber or dimension stock received is carefully inspected and its reception indicated by posting to a perpetual inventory maintained in the Planning Department, which shows location, description and quantity. The payment for the lumber is usually provided for by forwarding the tally sheet shown in Figure 16 to the cashier.

The next step in lumber control is the accumulation in the Planning Department on forms, similar to the one shown in Figure 20, of the lumber required to cover the various manu-

facturing orders which have been received by that department. This form is so designed that an assorted load of different thicknesses of the same kind of lumber may be accumulated if necessary. Its purpose is to indicate the lumber required to cut

KILN ORDER

Load No. .... Location ....

Thickness .... Kind ....

No. Bd. Ft. .... Kiln No. ....

A

SAMPLE IDENTIFICATION

Load No. .... Location ....

Thickness .... Kind ....

No. Bd. Ft. .... Kiln No. ....

B

MOISTURE RECORD

Load No. .... Location ....

Thickness .... Kind ....

No. Bd. Ft. .... Kiln No. ....

	Mo.	Day	Year	
Date to Kiln				.... % Moisture Green
Date to Cooler				.... % Moisture Dried
Date to Slasher				Bought of ....

C

FIGURE 21.—Form for Kiln Record

the available orders, which will be described more in detail under the description of the functions of the Planning Department. The amounts required are posted to a card until a full load is accumulated.

When the accumulation card indicates that lumber should be sent to the kilns for drying, a triplicate form as shown in Figure 21 is made out, and forwarded to the yard foreman which au-

thorizes him to place a load of a certain size from a certain location into a certain kiln pocket. The operation of this form has to be carried out jointly between the accumulation of lumber required in the Planning Department, and information furnished to the department as to available kilns by the yard foreman.

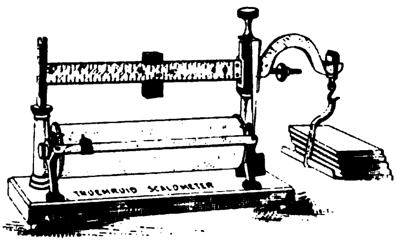


FIGURE 22.—Scale for Weighing Wood to Determine Moisture Content

When the yard foreman makes up such a load and places it in the kiln, he tacks upon it copies *A* and *B* of the form shown in Figure 21 and forwards copy *C* together with a sample of the green wood to the Planning Department. The Planning De-

Test and Move to Cooler Notice. MO. | DAY | YEAR

TAKE TEST PIECE FROM LOAD NO	KILN NO	IF TEST IS O.K. (Signed)	MOVE TO COOLER NO.	DATE MOVED TO COOLER

Please return to Planning Dept. after moving loads to Coolers showing dates moved

(Signed) ____________ Record Clerk

FIGURE 23.—Form for Order to Move Load from Kiln

partment weighs the sample green, dries it, weighs it again, and thus determines the percentage of moisture which is entered on copy *C*. Figure 22 shows a special indicating scale for weighing wood to determine the moisture content.

The Order Clerk in the Planning Department watches this file and from his knowledge of the time to dry certain kinds of lumber, makes out the form shown in Figure 23 when he considers that the load has been properly [illegible] of this

form, the Yard Foreman cuts a sample from the load indicated and sends it to the Order Clerk together with the form shown in Figure 23 and the sample identification, Form *B* (Figure 21). Form *C* (Figure 21) remains on the load. The Order Clerk tests the sample for moisture, and if it does not exceed 4 per cent (the

DELIVERY KILN DRIED LUMBER

MO.	DAY	YEAR

TAKE LOAD NUMBER	FROM COOLER NUMBER	TO CUT-OFF SAW NUMBER	ON DATE

(Signed) ______________ Record Clerk

FIGURE 24.—Form Ordering Lumber to Cut-off Saw

usually accepted satisfactory maximum moisture for use in furniture) he makes the proper entries on Form *C* (Figure 21), and on the form shown in Figure 23, returning this latter form to the Yard Foreman as his order to dispose of the load.

DELIVERY GREEN LUMBER

MO	DAY	YEAR

DATE	LOAD NO	FROM LOCATION	LUMBER		BD. FT.	[illegible] NO
			THICKNESS	KIND		

(SIGNED: ______________ RECORD CLERK

FIGURE 25.—Form for Delivery of Green Lumber

It will be noted that his form indicates removal from the kiln to a "cooler." The cooler is a dry warm pocket in which the load is held until its removal into the factory, to prevent its taking up moisture and to avoid leaving it in the kiln to cool gradually, thus unnecessarily holding up the kiln production. We do not advocate the use of the cooler when it can be avoided, but believed it best to outline the system of lumber control including it. Where possible provide adequate kiln capacity so that the loads may be cooled down within the pockets, or provide a standing

track in warm dry surroundings behind the cut-off saws for this purpose.

The Order Clerk maintains on a 3 inch by 5 inch card file

DELIVERY DIMENSION STOCK					MO.	DAY	YEAR
SIZE			LUMBER		PIECES OR	FROM	TO
LENGTH	WIDTH	THICKNESS	THICKNESS	KIND	BOARD PER FT.	LOCATION	MACHINE NO.

(Signed) ______________________
RECORD CLERK

FIGURE 26.—Form for Delivery of Dimension Stock

a record of all loads available in the cooler for taking into the factory. When a lumber accumulation card (Figure 20) shows that a load of kiln dried lumber is required, he orders it into the

FIGURE 27.—Form for Order Clerk's Record of Lumber Ordered in

kilns as outlined above. However, the usual practice is to keep an assortment of all kinds and thickness of dried lumber ahead of orders. In this case, or when the specially dried load of lumber is available, he orders it into the proper cut-off saw (obtaining this latter information from a list prepared by the

Schedule and Despatch Clerk), using a form such as that shown in Figure 24 for this purpose. When green lumber or dimen-

DIMENSION STOCK USED.

DATE	SIZE			LUMBER		PIECES
	LG.	W.	TH.	THICKNESS	KIND	OR BD. FT.

FIGURE 28.—Form for Order Clerk's Record of Dimension Stock Ordered in

sion stock is required he orders these similarly on the forms shown in Figures 25 and 26 respectively.

When lumber of any kind is thus ordered in, the Order Clerk

LUMBER REQUISITION

Yard Foreman: Please make up Load No. as follows and deliver to—Kilns—Saws—at

(Cross out either "Kilns" or "Saws")

A. M.	P M	MO.	DY.	YR.

PILE	THICK-NESS	GRADE	KIND	BD FT REQUIRED	ACTUAL BD. FT

FIGURE 29.—Form for Lumber Requisition for a Small Plant

notes the amount ordered in on the forms shown in Figures 27 and 28, these accumulations serving as the source of lumber cost information for the Cost Clerk. The Order Clerk also deducts, of course, the amounts used from his perpetual inventory cards (Figure 19).

There are various simplifications used in the control of lumber. One is the use of moisture gauges to control the operation of the kilns, thus doing away with the weighing of the samples. The author believes in the use of such instruments to assist in kiln operation, but has never yet been convinced that the actual test of samples for moisture was not essential, if a close moisture standard is to be maintained.

The principal benefits to be obtained from the use of such

control instruments are that excellent standard drying practice can be evolved for definite kinds and conditions of lumber by reference to the records which show the actual drying procedure both as to temperature and humidity for the best performances, thus providing knowledge for their duplication.

In a small plant, or where a high-grade yard foreman is available, aside from the keeping of the perpetual inventory, the entire lumber control may be operated with the two forms shown in Figures 20 and 29. The lumber requirements are accumulated as described above on the form shown in Figure 20 and the lumber ordered into kilns or saws on the form shown in Figure 29, depending upon the foreman for the control of moisture content and location in the kilns. While this is satisfactory in small plants, it lacks the clear-cut absolute control of the method outlined above, and cannot be termed scientific, as it depends largely upon the personality of the yard and kiln foreman.

We will next consider the control of the miscellaneous materials.

CHAPTER V

PURCHASING AND STORING

THE purpose of controlling the purchasing and storing of material is to

a Eliminate unnecessary purchases
b Prevent purchases at inopportune times
c Plan future purchases
d Keep quantity stocked of each material normal
e Prevent unnecessary capital being held up in stock
f Decrease cost of production
g Minimize delays in production.

Storekeeper

In the organizing of a Stores Department, the first problem is the selection of the proper individual as Storekeeper who will be in charge of the maintenance of the Stores Department under the authority of the Planning Chief. A Storekeeper should be physically able to handle without assistance the storeroom of a small plant. In a large plant assistants are of course necessary. He should be a fair penman and accurate in simple mathematics in order that the necessary records may be legibly kept. He should also be neat and systematic in order that the stores may be neatly and systematically maintained, avoiding delays through mis-location and damage to stock by carelessness or lack of cleanliness.

Standard List of Stores — Maximum and Minimum Requirements

The first duty of the Storekeeper should be to assist the Planning Chief or the organizing engineer in preparing a standard list of the materials to be stored with a maximum and minimum manufacturing requirement for each.

The setting of the minimum requirement is based upon the

supposition that the minimum should represent, with a fair margin for safety, a sufficient quantity of the store to supply the plant adequately during the period required to place an order for a new supply and receive it. In determining this factor consultation with the Purchasing Agent and Factory Manager is essential. At first it is advisable to set minimums high rather than low, in order to safeguard delays in production, but eventually all minimums should be placed as low as possible in order to prevent unnecessary capital investment.

The setting of the maximums should be based upon the size of order which the Purchasing Agent can best purchase to take advantage of quantity purchasing without exceeding legitimate capital investment, with of course consideration given to necessary manufacturing requirements. The list of standard stores and all minimums and maximums should be carefully gone over at least once every six months by the Storekeeper, Purchasing Agent and Works Manager for possible revisions.

Symbolization of Stores

After the preparation of this standard list of stores with its maximums and minimums, the question of the symbolization of these stores should be taken up. In many woodworking plants the range of materials required for storing is so limited that symbolization of stores is not required, but where thousands of articles must be carried in stock, symbolization will be found valuable in order to establish a standard nomenclature to designate each store. The following illustrates a symbolization of a portion of the miscellaneous stores carried in a furniture factory. This is given for illustration only, as it is the opinion of the author that in this particular case the list is so limited that no advantage was gained by such symbolization.

F. H. Screws	½–6	SF 1
	¾–6	SF 2
	⅝–8	SF 3
	¾–12	SF 4
	1–12	SF 5
	1⅛–12	SF 6
	1¼–12	SF 7
	1½–12	SF 8
	1¾–12	SF 9

	1–14	SF10
	1¼–14	SF11
	1¾–14	SF12
	2–14	SF13
	2½–14	SF14
	3½–14	SF15
	2½–16	SF16
O. H. Screws	1–8	SO 1
	¾–12	SO 2
	⅞–12	SO 3
	1–12	SO 4
	1⅛–12	SO 5
	1¼–12	SO 6
	1½–12	SO 7
	1¾–12	SO 8
	2–14	SO 9
	2¼–14	SO10
Rd. Hd. Screws	¾–12	SR 1
	⅝–10	SR 2
	1¼–12	SR 3
	1¾–12	SR 4
	2–14	SR 5
S. H. & G. P. Rod	3/16–11	R 1
	3/16–12½	R 2
Reg. Rod	3/16–10	R 3
	3/16–12	R 4
	9½	R 5
	3/16–12½	R 6
	3/16–18	R 7
W. B. Hd. Rod	3/16–23½	R 8
Shaft Bolt	1¾–3/16	BS 1
	2–3/16	BS 2
	2¼–3/16	BS 3
	2¼	BS 4
	2¼–¼	BS 5
Carriage Bolts	2¼	BC 1
	2¼–¼	BC 2
	2¼–5/16	BC 3
	2½–5/16	BC 4
	3–5/16	BC 5
	3¼–5/16	BC 6
	4–5/16	BC 7

		3⅜	BC 8
Sk. Hd. Bolts		2¼–5/16	BSk 1
		3¼–5/16	BSk 2
		3½–5/16	BSk 3
		4½–⅜	BSk 4
Lag Bolt		4½–⅜	BL 1
Hanger Bolt		2½–⅜	BH 1
Hanger GP		4⅜	BH 2
Stove Bolt		3/16–2	BSt 1
Rivets		1–3/16	Rt 1
WB Hd.		1¼–3/16	Rt 2
WB Hd.		2¼–5/16	Rt 3
Rd Hd.		1¾–¼	Rt 4
Washers		3/16–20	W 1
		¼–20	W 2
		5/16–18	W 3
		⅜–17	W 4
Chair Irons		15½ Office	I 1
		17½ Base	I 2
		Baby Base	I 3
		Typewriter	I 4
Chair No. 258		Milw. Stool	I 5
		4A Screw	I 6
		364–20	I 7
		364–24	I 8
		364–30¾	I 9
		354–21	I10
		354–24	I11
Hubs 1		15½–17½	H 1
2		Typewriter	H 2
3		Milw. Stool	H 3
Fold. Chair Iron	No.	1	112
Corner Castings			CC
H. C. Castings	No.	201	HC 1
		204	HC 2
		205	HC 3
		206(1)	HC 4
		206(2)	HC 5
H. C. Catch post		1⅛	HC 6
No. 1		Beveled	HC 7
Castors Yale	No.	123	CY
Evergrip		⅝	CE

Plug Oak		17/32 × 5/16	P2
Buttons Oak		3/8 × 5/16	P1
Plugs Birch		17/32 × 1/2	P3
Rubber Tips	No.	19	T1
Screw Bumpers	No.	1	BmS
Tack Bumpers			BmT
D. P. Brads		3/4–16	BrD1
		7/8–16	BrD2
		3/4–17	BrD3
		1–16	BrD4
		1 1/4–16	BrD5
		1 1/2–15	BrD6
Nails		3d com	N1
		6d fine	N2
		1–16	N3
		4d com	N4
Barbed Nails		1 1/4–16	NB1
		5/8–16	NB2
Brads		5/8–19	Br1
		7/8–16	Br2
Bung Hd. Brad		3/4–16	BrH1
		1 1/4–16	BrH2
Superfine Cane strands		27S–8 3/4	C1
		33S–10 3/4	C2
No. 1 NM		27S–15 1/2	C3
		25S–13	C4
Reed or Pith Web		9 1/2 (Width)	PW1
		13 (Width)	PW2

Location of Stores Department

With the stores classified and symbolized we next take up the actual design of the Stores Department. The stores should be located in such a position in the plant that incoming materials may be readily delivered to it. In determining this point it is necessary to consider whether the materials are received by railroad, which would require the department to be located near a railroad siding, or whether the bulk of material is received by team. An additional consideration in the location of the store- is that it should be conveniently located to the manufac-

turing points utilizing the bulk of material stored. Sometimes storerooms must be established in several different locations to adequately cover this last point. This is usually true of the storage of finishing and upholstering materials.

Equipment of the Storeroom

In constructing the storeroom considerable thought and study is essential. Bins and storage spaces must be so constructed that material can be conveniently stored and removed. They must also be large enough to take care of the maximum manufacturing requirements. They should likewise be so constructed that an inventory can be easily taken at any time.

Bins, racks, or the storage spaces, when possible, should be of standard steel type which may be readily bought from many dealers. However, where the material to be stored is of unusual size, or when the manufacturer does not wish to invest the capital required for steel bins, they may be constructed of wood, Steel, however, has been found far more satisfactory and economical in the end if sufficient thought is given to the original design.

The aisles or passageways between the various sections should be wide enough to allow the proper conveying devices (such as trucks) to be utilized. For small hardware parts, such as screws, a good arrangement of bins is to design them in such a way that when the bin is absolutely full it holds the maximum manufacturing requirement, but when it is full only to the level of the front section it will hold approximately the minimum requirement. This serves as an automatic notice of the reaching of the minimum stock requirement.

Symbolization of Stores Department

The symbolization of the storeroom is a matter which is often carried out with little idea of actual utility of such symbolization. The author has found the following method very satisfactory, inasmuch as this not only serves as a nomenclature for the various bins, but also indicates the location of each bin automatically:

Sides or Racks—consecutive *odd* numbers to left of aisle from point of entry; consecutive *even* numbers to right of aisle from point of entry.
Tiers or Stacks—Alphabetically, *away* from aisle.
Bins—Numerically, beginning at bottom, upwards.

Figure 30 illustrates this symbolization graphically.

Perpetual Inventory

As soon as the Stores Department has been completed, the material should be put away in the proper bins. On each bin

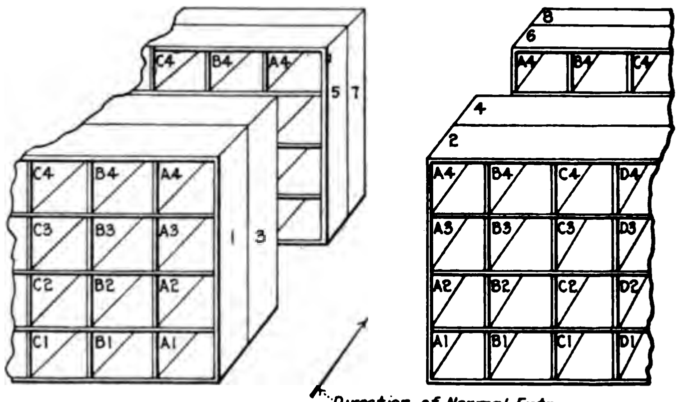


Figure 30.—Symbolization of Storage Bins

should be placed a tag such as shown in Figure 31, the heading of the tag being properly notated with the maximum and minimum requirements, location, name and size of article, and the amount on hand entered in the Balance column. At the same time, a Perpetual Inventory card as shown in Figure 32, should be posted. When all material has been thus located, the Perpetual Inventory cards should be sent to the Stores Clerk in the Planning Department. The Storekeeper should also maintain a file on 3 inch by 5 inch cards alphabetically indexed by articles and by sizes, thus showing the various locations in which each article is stored. Sometimes this is avoided by maintaining the location of articles on the perpetual inventory cards in the Planning Department and showing the location on the material requisition when this is written. Usually this is not feasible, however, in a woodworking plant.

Material Reservation and Requisitions

When the Order Clerk writes up manufacturing orders as described in the next chapter, he makes out material requisitions such as shown in Figure 33, making the necessary posting in the

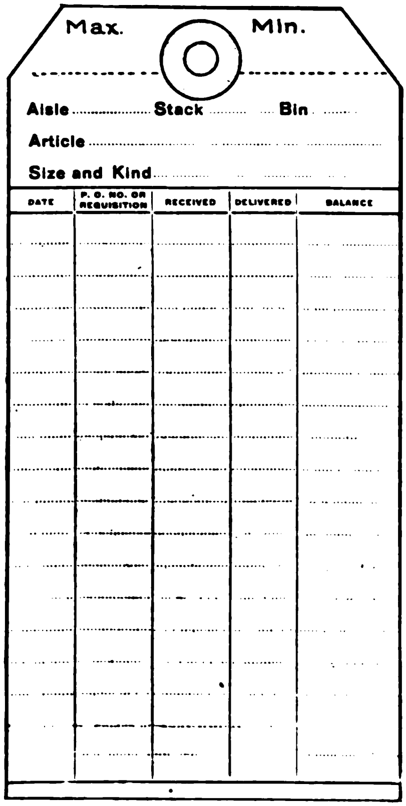


Figure 31.—Form for Stock Bin Tag

Delivered column on the Perpetual Inventory card (Figure 32), and adjusts the balance. In some plants where orders are accumulated some time in advance, a form such as shown in Figure 34 is used to reserve materials, which is handled in practically the same manner as a material requisition so far as the Planning Department is concerned, until the material is actually used, when a material requisition (Fig. 33) is written. This is seldom essential, however, in a woodworking plant.

Disbursement of Materials

When the material requisition is received from the Planning Department together with a manufacturing order as described

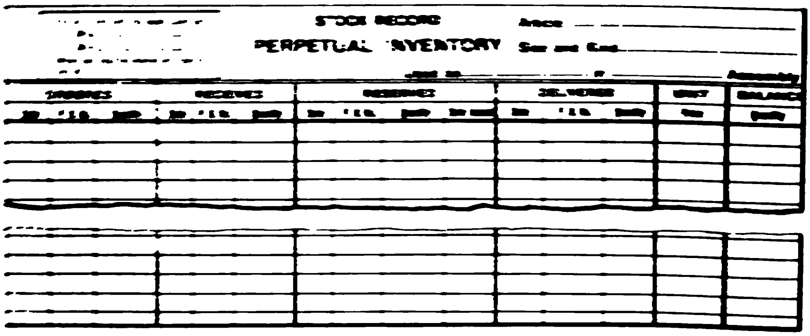


Figure 32.—Form for Perpetual Inventory Card

in the next chapter, it is presented to the Storekeeper for filling. The Storekeeper first refers to his location file for the location in which the material is stored; he then withdraws it, noting the requisition number, date, and amount delivered on the bin tag

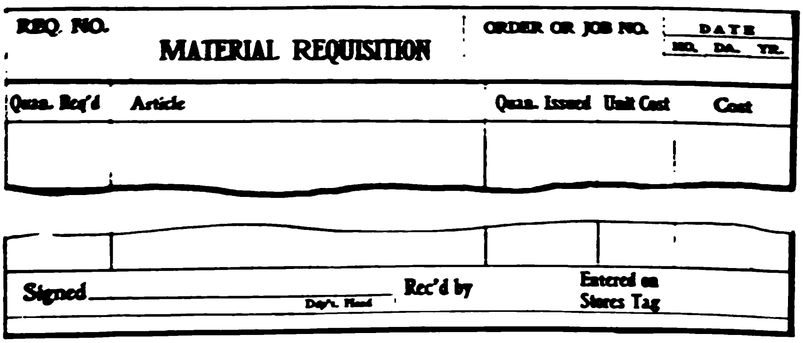


Figure 33.—Form for Material Requisition

(Figure 31) adjusts the balance thereon, and delivers the material to the person presenting the requisition, forwarding the requisition to the Planning Department.

Should there be more material received in a department than is required for immediate use on the order designated, a stores credit such as that shown in Figure 35 is made out and re-

turned with the goods to the storeroom, where it will be handled practically the same as goods received on a receiving slip as de-

STORES RESERVATION			DEP'T. NO.	DATE		
				MO.	DA.	YR.
Order or Job No.	Quantity	Article		DATE ISSUED		
				MO.	DA.	YR.
Signed ______ Planning Dept. Chief			Entered on Stores Tag			

FIGURE 34.—Form for Stores Reservation

scribed on page 70, after which the stores credit will be forwarded to the Planning Department for the proper notation on the Perpetual Inventory card (Figure 32) and then to the Cost

Stores Credit	From Dept.		F.O. No.				No.
Reason:							Mo. Day Yr.
Quantity	Description					Unit Price	Value
	Mo.	Day	Yr.	Initial	Foreman's Initials		
Entered on Stores Inventory							
Entered on Cost Summary							

FIGURE 35.—Form for Stores Credit

Department where it will be handled as described in Chapter XV under costs. We have now covered the disbursement of material, from the original stock and will take up the purchase of additional stock and its handling in the Stores Department.

THE PURCHASE REQUISITION

When a particular store has reached its minimum requirement as shown by the bin tag (Figure 31) a purchase requisition such as that shown in Figure 36 will be made out for the maximum re-

quirement of the article by the Storekeeper, who will place a check mark against the space Classified Material. Purchase requisi-

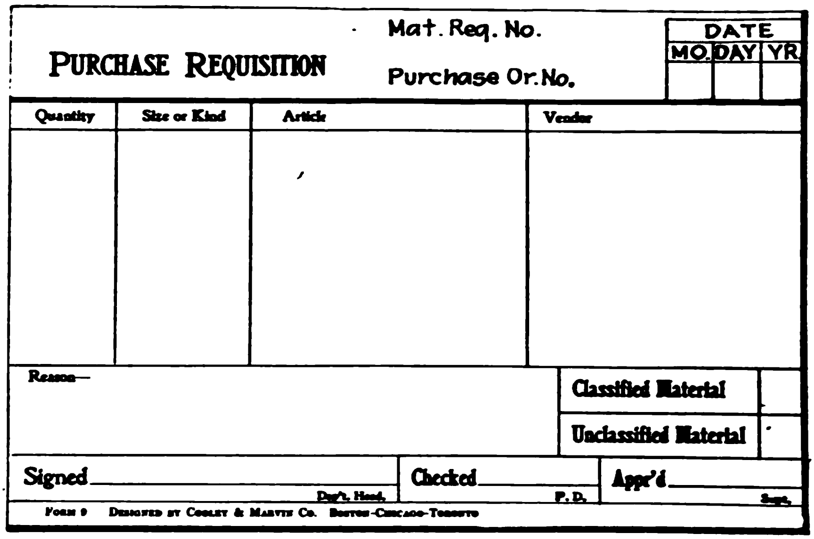


FIGURE 36.—Form for Purchasing Requisition

tions made out by the Storekeeper for such classified materials will be sent directly to the Purchasing Agent and will serve as his authorization to purchase the material. When special ma-

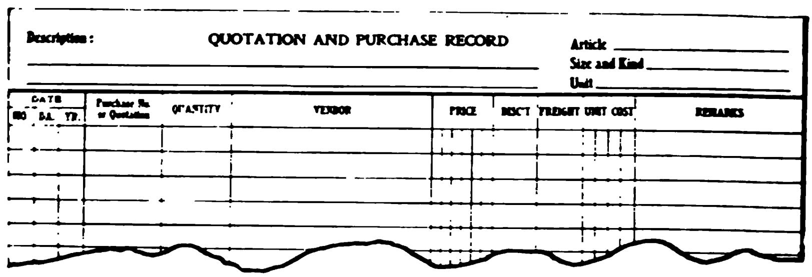
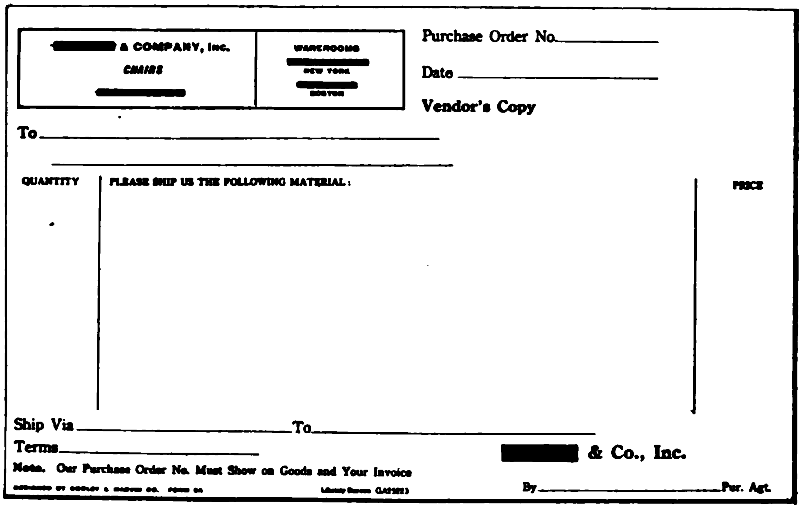


FIGURE 37.—Form for Quotation and Purchase Record

terials such as tools, etc., that is, unclassified materials, are required, a purchase requisition will be made out by the department head requiring such material with a check against the space Unclassified material (Figure 36). Such requisitions must be O.K.'d by the General Manager before they become an authorization for the Purchasing Agent to purchase such material.


[redacted] & COMPANY, Inc.
CHAIRS
[redacted]

WAREROOMS
[redacted]
NEW YORK
[redacted]
BOSTON

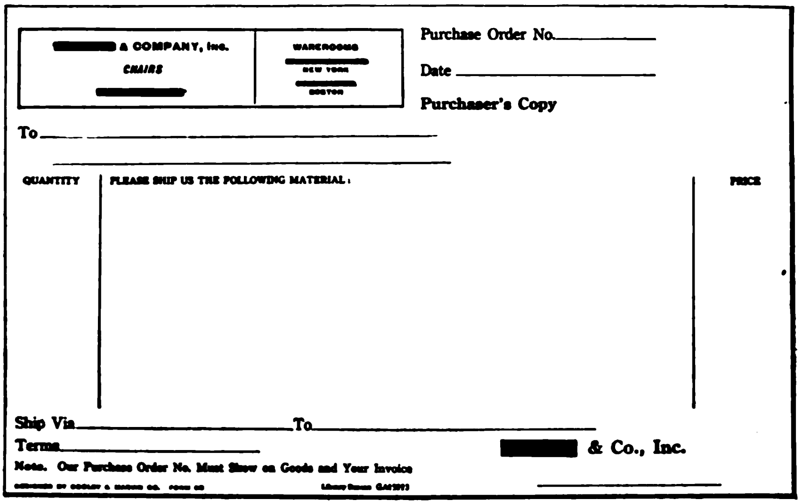
Purchase Order No.____
Date ____
Vendor's Copy

To____

QUANTITY | PLEASE SHIP US THE FOLLOWING MATERIAL: | PRICE

Ship Via____ To____
Terms____
[redacted] & Co., Inc.
Note. Our Purchase Order No. Must Show on Goods and Your Invoice
By____ Pur. Agt.

FIGURE 38.—Form for Original of Purchase Order


[redacted] & COMPANY, Inc.
CHAIRS
[redacted]

WAREROOMS
[redacted]
NEW YORK
[redacted]
BOSTON

Purchase Order No.____
Date ____
Purchaser's Copy

To____

QUANTITY | PLEASE SHIP US THE FOLLOWING MATERIAL: | PRICE

Ship Via____ To____
Terms____
[redacted] & Co., Inc.
Note. Our Purchase Order No. Must Show on Goods and Your Invoice

FIGURE 39.—Form for Purchase Order as Filed by Purchase Agent

PURCHASING

Upon receipt of the Purchase Requisitions properly authorized, the Purchasing Agent will obtain quotations for the material required and record the final quotation selected on a quo-

tation and purchase record such as that shown in Figure 37. Upon the selection of the vendor, the Purchasing Agent will note the vendor's name in the proper column on the purchase requisition (Figure 36) from which a stenographer will write the original and two duplicate purchase orders shown in Figures 38, 39, and 40. The original (Figure 38) will be sent to the vendor; the first copy (Figure 39) will be filed by the Purchasing Agent; and the receiving clerk's copy (Figure 40) will be forwarded to the Storekeeper, who, in most woodworking factories, can act as

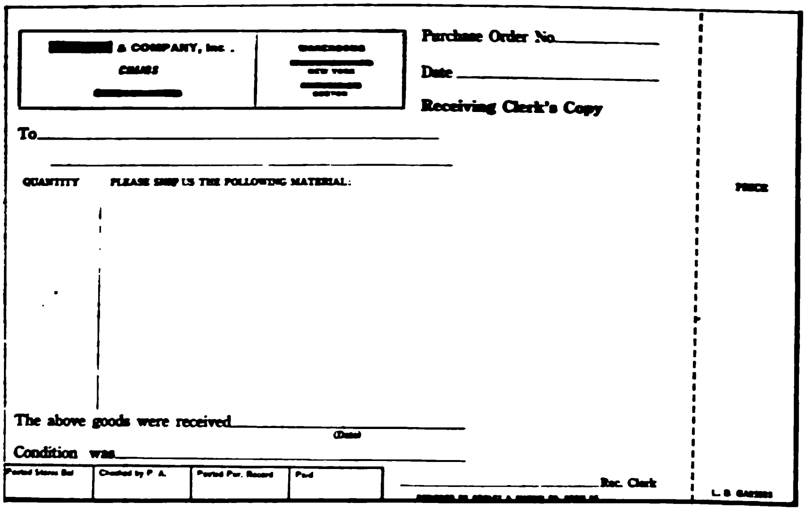


FIGURE 40.—Form for Receiving Clerk's Copy of Purchase Requisition

the receiving clerk as well. In the typing of the purchase orders, a short carbon is used between the first and second copies, so placed that the quantity is not shown on the receiving clerk's copy, and by tearing off the right-hand edge on the dotted line, the price is not known.

RECEIVING

When materials are received, the Receiving Clerk locates his copy of the purchase order covering such goods, inspects them for quality, and if satisfactory, enters the quantity received in the proper column. If the materials are classified stores, he places them in the proper location, entering the number of the purchase order, the amount received and balance in the proper columns on the bin tag (Figure 31), and forwards the receiving

copy of the purchase order to the Stores Clerk, who will make the proper notations on the perpetual inventory card (Figure 32) and who will then forward the receiving copy of the purchase order to the Purchasing Agent. If the quantity and quality have been found correct, the Purchasing Agent will attach the receiving copy to his copy of the purchase order (Figure 39) with the proper notations and forward them to the Cashier who will pay the account.

Should a partial shipment only be received, the Receiving Clerk will report subsequent partial shipments on receiving copies of the purchase order, a supply of which will be furnished him in blank and which will be handled in the same manner as a complete shipment described above.

Any shortage of quantity can be adjusted by the Purchasing Agent with the vendor from the information automatically furnished by the Receiving Clerk and the inspection by the Receiving Clerk will determine any deficiencies in quality which the Purchasing Agent can take up with the vendor.

In a woodworking plant the duties of the Storekeeper are not usually heavy, as the miscellaneous materials used are slight. He usually is held responsible for the perpetual inventory of lumber, but delegates the actual control of this material to the Yard and Kiln Foreman as described in Chapter IV.

The above outlined method effectively controls the materials of the industry in a simple effectual manner. We will next consider the control of production by the Planning Department.

CHAPTER VI

PLANNING DEPARTMENT

The basis of information sent to the Planning Department as to what is to be manufactured, is furnished by manufacturing orders made out in the main office from the customers' order. They are transcriptions upon a uniform form of the customers' orders and they thus furnish all of the primary knowledge needed by the factory as to what product is to be shipped to certain customers. The manufacturing order is usually made out in triplicate on forms similar to those shown in Figures 41, 42, and 43. The original or office copy (Figure 41) is retained in the

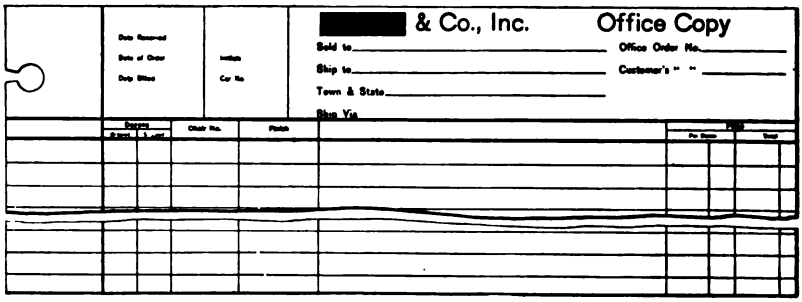


FIGURE 41.—Form for Original of Manufacturing Order

office until the shipping copy (Figure 43) is returned from the shipper with notations showing that the order has either been shipped complete or in part. The amount shown on the shipping copy is then checked onto the office copy and the price of the amount shipped extended, after which the office copy serves as a source for billing the customer. When partial shipments are made, a copy of the balance of the order is made out on the same three forms with the same order number followed by a letter B and a large open-face rubber stamp is used to notate Back Order across the face of each sheet. This prevents any possibility of the balance of the shipment being neglected in the case of part orders.

ACCUMULATION OF ORDER DATA

The accumulation or summary of order requirements in the Planning Department depends upon whether the factory manufactures to stock or to order. Where the line is properly standardized it is possible to manufacture to stock, but in the majority of furniture manufacturing concerns manufacturing is controlled by the orders received rather than by making any attempt to manufacture stock, from which customers' orders could be shipped.

When it is possible to manufacture to stock, a form similar to that shown in Figure 44 may be used. One of these is made out for each item of product with a notation showing the maxi-

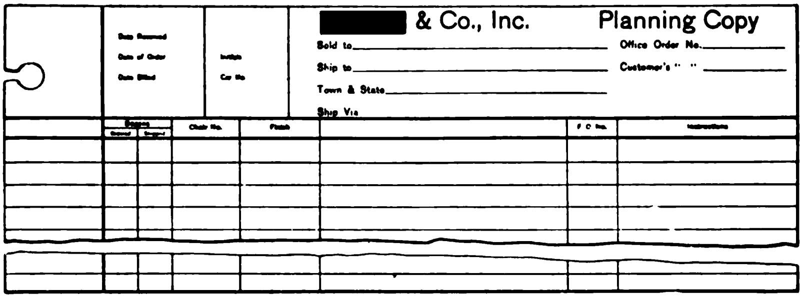


FIGURE 42.—Form for Planning Department Copy of Manufacturing Order

mum and minimum stock requirements and the standard sized order to automatically manufacture at certain periods or when the stock reaches the minimum. The setting of the maximum and minimum for each item should be done by the Sales Manager as they primarily depend upon sales conditions. The normal size of order to manufacture should be set by a conference between the Sales Manager, Works Manager, and Planning Chief, in order that it may not interfere with the sales, manufacturing, or processing requirements. For instance, a certain item might be a particularly heavy runner requiring say, the manufacture of 30,000 units per month, but if the normal order was made a monthly order of 30,000, whenever this unit was put into process it would seriously hold up other orders. Therefore in such a case a weekly order of 7500 might be preferable. Of course the standard orders would be as large as possible in order to take advantage of the increase in manufacturing efficiency due to the saving in machine setting required and avoidance of change of workmen.

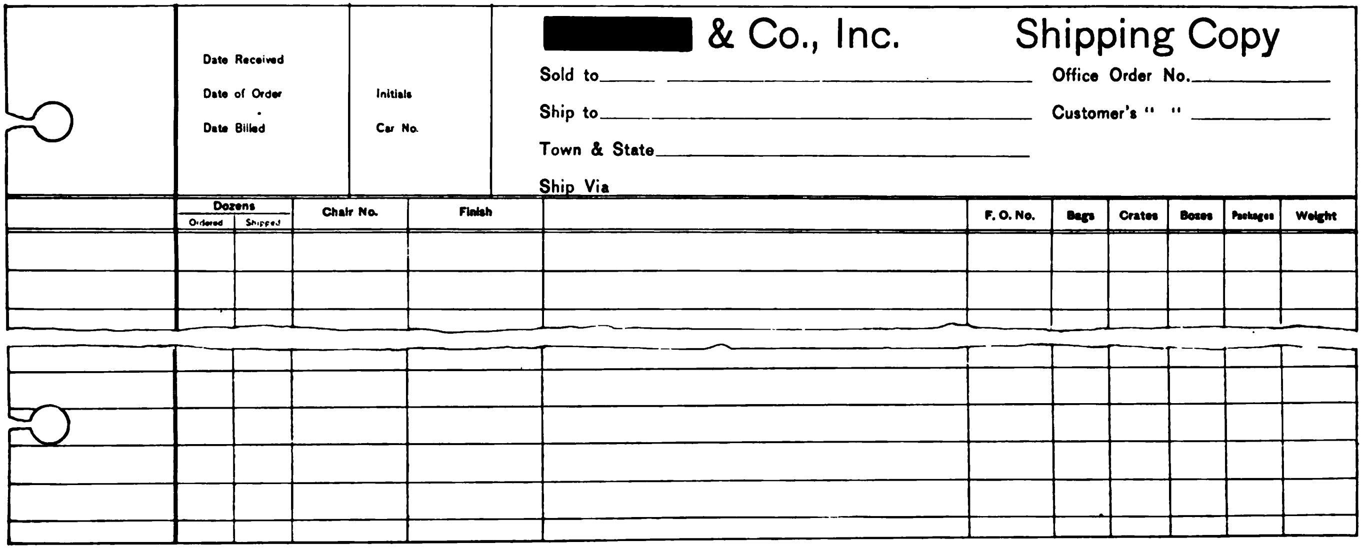


FIGURE 43.—Form for Shipping Copy of Manufacturing Order

When manufacturing stock and using the form similar to that shown in Figure 44, as each order is put into process the number of units is notated in the column Number against the proper date and order number. As the various manufacturing orders are received requiring this unit, they are posted showing the order number and number of units in the Applied columns (Figure 44). When the application of these orders shows that the stock order has been exhausted until only the minimum requirement remains available, an additional stock order should be put into process.

The proper size of the normal manufacturing stock order can be automatically controlled by close examination of this

APPLICATION OF STOCK ORDERS

DATE PROC'D	STOCK ORDER NO.	CHAIR	FINISH	NO	APPLIED									
					ORDER	NO	ORDER	NO	ORDER	NO	ORDER	NO	ORDER	NO

FIGURE 44.—Form for Posting Manufacturing Orders as Received

posting. Suppose that a normal order is 5000 units once a month, but inspection of the application shows that the previous stock order of 5000 satisfied the customers' orders for a period of two months. This automatically indicates that the unit is losing its sales and the stock order then to be processed should be reduced. In making changes in these manufacturing orders, the Works Manager, Sales Manager, and Planning Chief should be consulted. On the other hand, supposing that the normal manufacturing order is 5000 processed once per month, but that the entire 5000 has been exhausted by customers' orders in one week. This immediately indicates that either the size of the order must be increased, or that it must be manufactured more frequently. In spite of the varying lines of many furniture concerns and the remarkable fluctuations of the sales of various items, it has been shown that by the proper use of the above method almost any woodworking factory will be enabled to manufacture to stock. A careful constructive examination of the application

of stock orders, on a form such as shown in Figure 44 and described above, as a basis for the processing of stock orders should prevent any accumulation of dead stock which would have to be disposed of at a discount. The entire sales situation is constantly before the eye of the clerk handling the record and any falling off in sales can be met by decreasing the manufacturing requirements as well as unusual increases may be met without delaying deliveries, as is so often the case in factories which endeavor to manufacture simply to cover their current order requirements.

When it is necessary to manufacture or process orders only as fast as customers' orders are received, a form similar to that

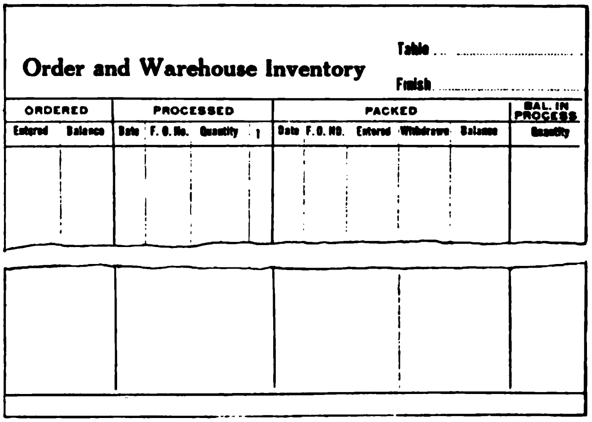


FIGURE 45.—Form for Summarizing Manufacturing Orders

shown in Figure 45 is useful. The customers' orders are summarized daily from the Manufacturing Orders (Figure 42) and posted in the Ordered column of Figure 45 together with the balance to date. When a sufficient balance is accumulated, an order is processed and notated in the Processed column of Figure 45. This balances the processing against the orders received. This form may be further utilized to record the number of units of the product packed and shipped, thus giving a balance of the particular unit in process throughout the entire factory at any time.

SHAPED AND MACHINED STOCK

Whether it is decided to manufacture to stock or to order, a fundamental principle applicable to the majority of furniture

PART SYMBOL F-6

F-6

LAYOUT FOR D-1

NO. PCS. PER CHEST ONE KIND OF WOOD RED CEDAR

CUTTING LENGTH	SIZE AT LINDERMAN	FINISHED SIZE
41-1/2	41-1/2 - 13-11/16	40 - 13-1/2 x 3/4

BOARD FEET PER 100 PANELS OR PIECES 370

STYLES ON WHICH THIS PART IS USED

2640	2644	2619		
2641	2689			

OPER SYMBOL	DESCRIPTION	RATE	T A 100 PIECES
CO 1-2	Cut off to 41-1/2	1	
PSS-3	Surface to 15/16	1	
RB-4	Edge		
G	(FRONT) Grade	20	.92
JL 6-7	Build panels	2	.92
JH-8 P -9	Joint 1 edge and Dress to 13/16	6	.50
WST-10	Size to width	7	.14
LST-11	Size to length	7	.14
BL-14	Cut for lock	4	.64
BM-13	Bore	5	.52
SDM-12	Mach. sand 2 sides	8	.67
		TOTAL	4.45

FIGURE 46.—Manufacturing Layout Sheet

plants and most woodworking concerns, is that certain parts of units of product may be manufactured to stock with two classifications, namely, "shaped stock" and "machined stock." By shaped stock is meant the manufacture of interchangeable parts without any of the fitting or machine operations. For instance, a certain size panel for a piece of case goods, or a leg for a table, may be used in several units of product, but with different fitting operations. Advantage of quantity production should be taken in this case to manufacture the part through to the point where the operations are uniform. Such a part which has usually been given its fundamental shape but which has not been machined is known as shaped stock. When such shaped stock has been put through the various fitting operations and is ready to be assembled with other parts into the complete unit, such stock is then known as machined stock.

Therefore, when goods are to be manufactured, the first requirement, after the size of the order has been decided upon, is to determine which of the following methods of manufacture shall be employed: (1) can they be assembled from machined stock; (2) can shaped stock be turned into machined stock and then assembled; (3) shall the manufacturing process begin with the raw material; or (4) shall a combination of these processes be used. To provide the proper basis for such control, storerooms with racks and bins controlled by perpetual inventories must be created for both shaped and machined stock, their construction and control being practically identical with that described in the previous chapter using the same perpetual inventory form as shown in Figure 32, bin tags such as shown in Figure 31 and symbolized as shown in Figure 30. The perpetual inventories of shaped and machined stock are maintained in the Planning Department by the Stores Clerk. Having now shown the method in which the Planning Department is advised as to the manufacturing requirements, we will discuss the fundamental records required.

Layout Sheets

The primary record is the layout sheet showing all the necessary information for manufacturing an article of product. In various woodworking plants we have used two types of layout sheets shown in Figures 46 and 47 respectively. Figure 46 is a unit layout sheet, that is, a sheet showing the manufacturing de-

tails for a single part of furniture, while Figure 47 shows the complete layout sheet for manufacturing the entire unit of product. While the latter is usually a very large, clumsy form, it has been found far more effectual than the former sheet for the small number of interchangeable parts in the woodworking industry does away with the advantage of the unit layout sheet. After all the possible standardization and development of interchangeable parts in a furniture factory has been carried out, there remain certain individual machining operations required by practically every different unit of product into which the part goes, thus requiring an individual layout sheet for practically every part in every unit of product. The complete layout sheet shown in Figure 47 gives all the information required in one place for manufacturing the unit of product. Sometimes both forms are used, unit layout sheets being made up for the manufacture of interchangeable parts through the point where their variable machining begins; that is, shaped stock (these parts are manufactured and carried in stock) and the complete layout sheet showing their withdrawal from such stock and outlining the individual specific machining operations required for the assembly or unit in which they are to be used.

The layout sheet is made out by the Standards Clerk from information collected as to materials used from the records or usually from the knowledge of the various members of the old organization, and recorded in a uniform manner. The manufacturing data such as the sequence of operations, machines, bonus rates, times allowed, and controlling standard instructions are furnished by the time study men and Works Manager or Shop Superintendent as standard manufacturing methods are evolved as described in Chapter VIII. The principal thing to be borne in mind in creating the layout sheets is that absolutely all information must be shown which is necessary for preparation of the factory orders.

The summary of order requirements and the maintenance of the layout sheets is controlled by the Order Clerk as described in Chapter II on organization although, of course the preparation of the layout sheets as previously stated is a duty of the Standards Clerk.

Making Out Production Orders

When it becomes necessary to process goods ... Clerk,

LAYOUT SHEET.

Chair No.________

Part																				
○ per Chair																				
Sq. Ft. per 100 pcs.																				
Size	Rough	Finished	Rough	Finished	Rough	Finished	Rough	Finished	Rough	Finished	Rough	Finished	Rough	Finished	Rough	Finished	Rough	Finished	Rough	Finished
L																				
W																				
T																				
Finish	Wood		Wood		Wood		Wood		Wood		Wood		Wood		Wood		Wood		Wood	
○																				

	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.	Oper.	Mch.	Rate	T.A.	S.I.
Operations Prior to Shaped Stock.																																																		

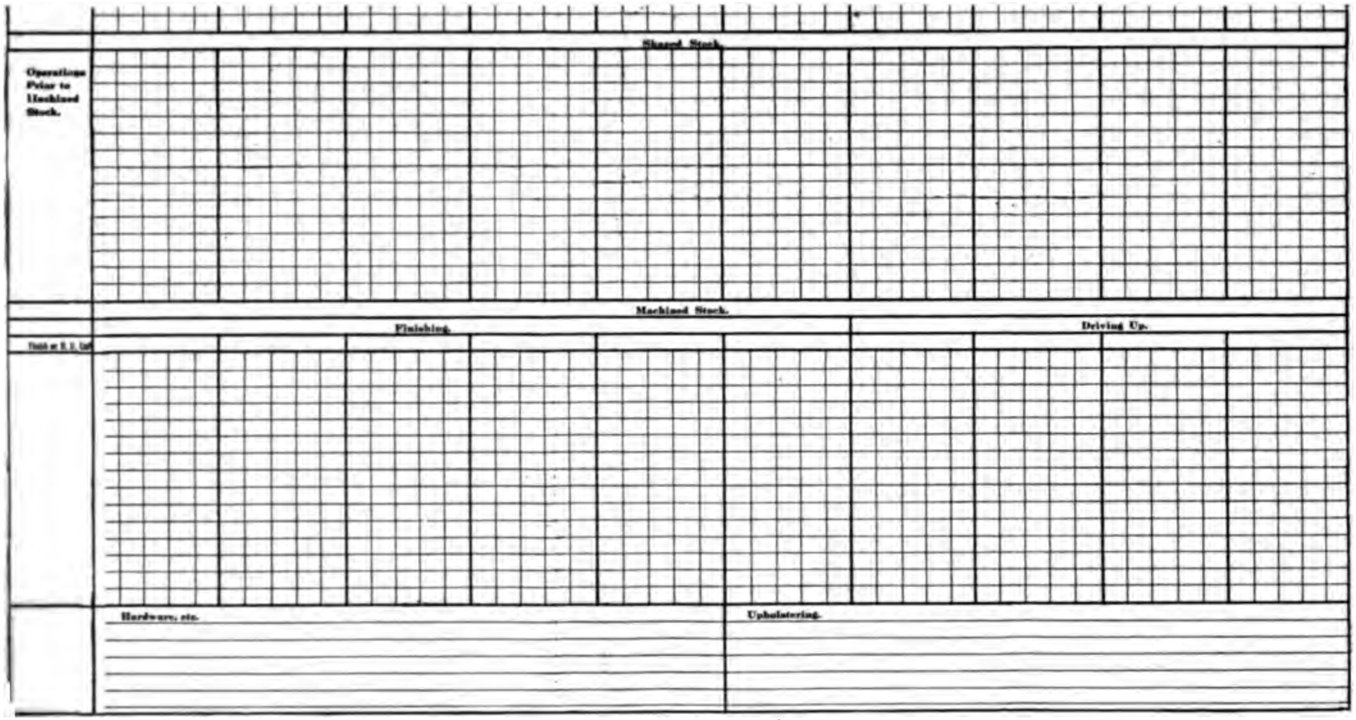


Fig. 47

FIGURE 47.—Complete Layout Sheet for Manufacturing an Entire Unit of Product

LAYOUT SHEET. (CONTINUED.)

Chair No.________

Part										
No. per Chair										
Bd. Ft. per 100 pcs.										
Size	Rough / Finished	Rough / Finished	Rough / Finished	Rough / Finished	Rough / Finished	Rough / Finished	Rough / Finished	Rough / Finished	Rough / Finished	Rough / Finished
L										
W										
T										
Finish	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Wood
	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.	Oper. / Mch. / Rate / T.A. / S.I.
Operations Prior to Shaped Stock.										

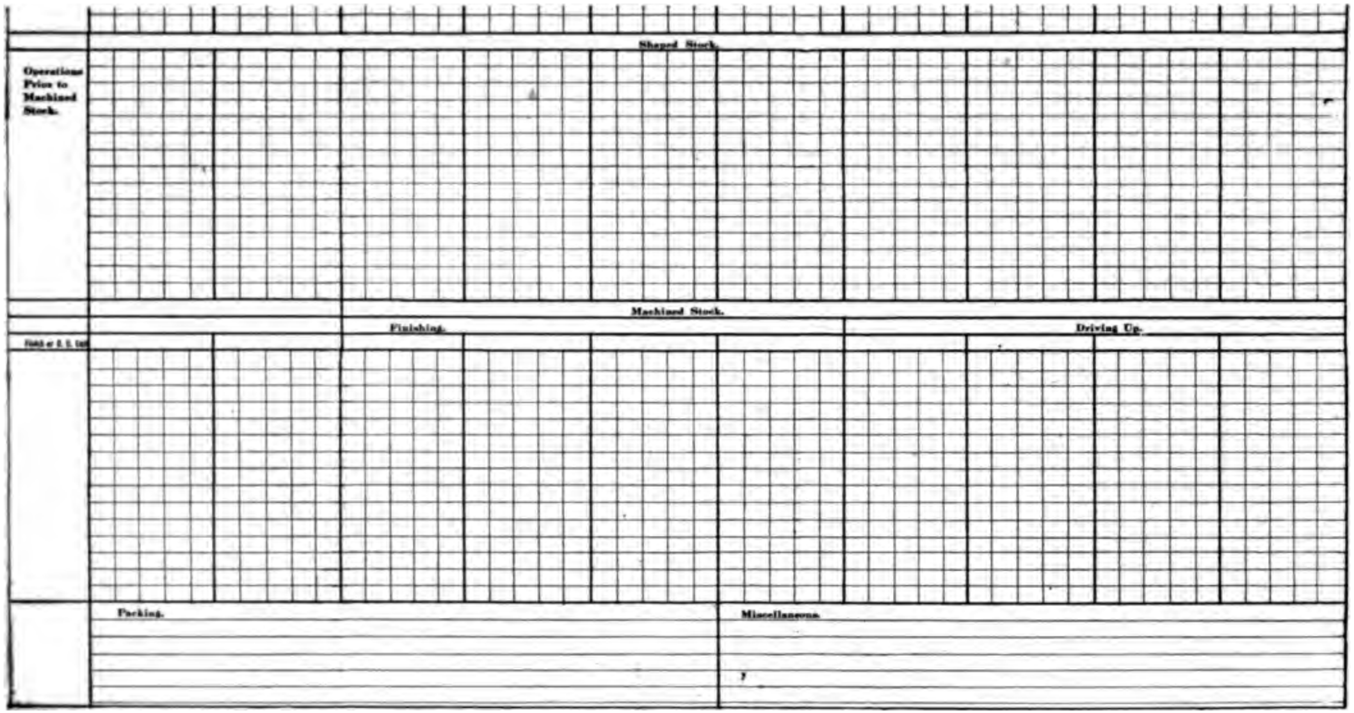


FIGURE 47.—Continued – Reverse of Complete Manufacturing Layout Sheet

after determining the size of the order to be processed as described above, takes from his file the layout sheet covering the unit of product to be manufactured and refers to the perpetual inventories of shaped and machined stocks, maintained by the Stores Clerk, to determine if the order can be manufactured from such stock or whether it is necessary to manufacture it in whole or part from lumber. The files of these perpetual inventories

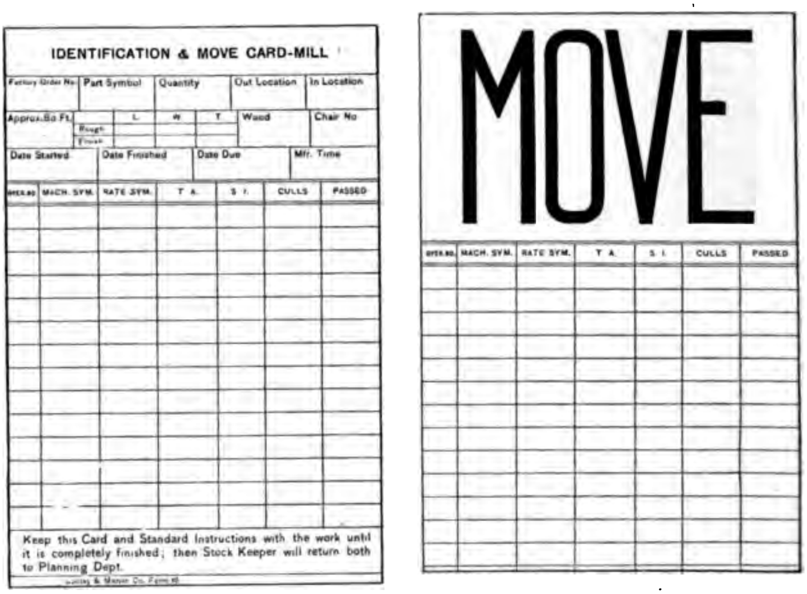


FIGURE 48.—Form for Identification and Move Card

must therefore be located where both the Order Clerk and Stores Clerk can have ready access to them. It is usually the case that certain parts must be manufactured complete while certain others can be drawn from the two stock rooms. In any case, production orders such as those shown in Figures 48 and 49 are made out.

Figure 48 serves either to withdraw from shaped stock, to manufacture a part completely from lumber, or a combination of these procedures. One form is made out for each part required by the unit. On this form complete information required to manufacture the part is copied from the layout sheet.

The word Move on the back of the form is for the purpose of showing when an operation is complete, the Production Order is reversed and so placed in a clip on the truck that the word indicates to the Inspection and Move Boss on the floor that the

truck is ready for inspection and moving to the next operation, which will be described later. When this form is used for the manufacture of either shaped or machined stock, it serves as a notice of the entry of such an amount of stock into the stockroom and is a source for posting such information to the perpetual inventory maintained in the Planning Department. The use of this card as a withdrawal or entry slip is accomplished by the insertion of a location symbol in the Out Location space by the

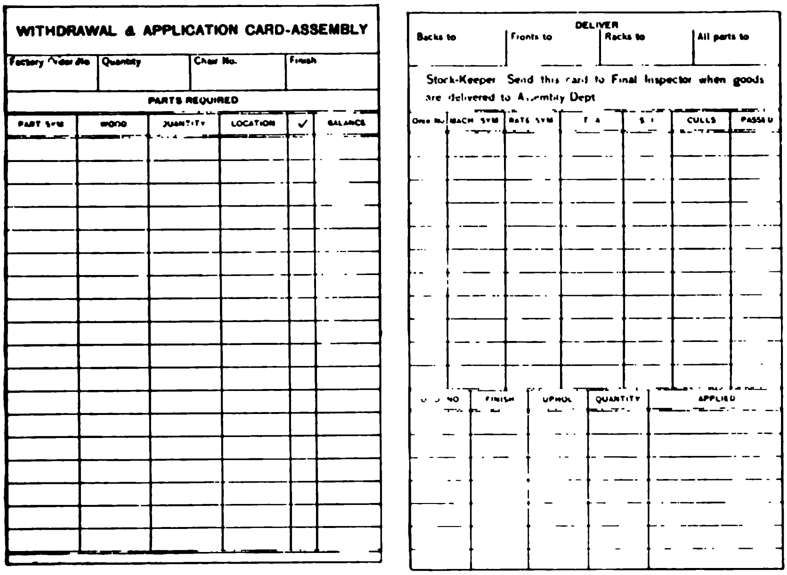


FIGURE 49.—Form for Withdrawal Order from Stock Room

Order Clerk or in the In Location space by the Stores Clerk respectively. It will also be noted that spaces are provided for the insertion of a record of the number of culls made on each operation, which is an important factor in the waste control, which will be described later.

Should sufficient stock be found in machined stock to make the order completely, a production order such as shown in Figure 49 is used, which acts as a withdrawal for such stock from the machined-stock room and indicates the point to which it is to be delivered in the Assembly Department. It also gives the standard information for manufacturing details on the reverse side similarly to that shown in Figure 48.

In addition to serving as a withdrawal and ass

the last few lines on the reserve side of the form provide for the application of the manufactured order against the proper customers' oders. This is provided for by entering in the space O.O. No. the office order numbers which are to be covered by this manufacturing order, together with the necessary information as to the finishing, upholstering, etc. Between the Assembly and the Finishing Departments is located an Inspector. All forms shown in Figure 49 are sent to him after the work has started in process in the Assembly Department. As the finished product comes to him in the white, that is, direct from the assemblers, without finish, he places a sticker or tag on each unit as he approves it showing the office order number against which this is to apply and indicates thereon the necessary instructions for finishing or upholstery, as shown on the reverse of Figure 49 and as he passes each unit tallies it in the Applied column on Figure 49 until the entire order has passed him and been applied. The product after completion in the finishing and upholstering department goes to the Shipper who assembles it in lots of similar office order number ready for shipment.

In case certain parts must be manufactured, that is, if the complete number of necessary parts are not shown in the machined stock room by the perpetual inventory, the assembly order (Figure 49) is not issued until those parts have been manufactured on the part orders shown in Figure 48. Provision is made for checking this fact on the assembly form by providing the V column. An assembly order is never put into process until every item shows this check mark which is placed thereon when the perpetual inventory shows the required number of parts in machined stock.

Lumber Requirements

In case certain parts must be cut from lumber, reference is made to the file of lumber required forms (Figure 20) which is maintained by the Order Clerk and which was described in Chapter IV in the description of lumber control. If it is found that sufficient orders have not been received to cover the cutting of an entire load of the particular kind of lumber required, the Order Clerk will consult with the Planning Chief as to what shaped stock parts in addition may be safely ordered to consume the entire load. In other words, a load of lumber is not ordered into

the cutting-off saws until sufficient part orders are accumulated or parts can be cut for stock to entirely utilize the load.

Cutting Assortment

In accumulating the lumber requirements which are posted to the form shown in Figure 20 by the Order Clerk from the manufacturing orders received, the question of waste must be borne in mind. If waste is running at say, 20 per cent, the lumber required to cut the orders on hand must be increased 20 per cent to cover this wastage. An additional point to be considered in ordering lumber for cutting is that a sufficient range of sizes must be provided to utilize the lumber effectually. For instance, if a considerable number of 38 inch rockers is required, orders for two or three other parts requiring stock but 10 or 15 inches in length are essential, as it is impossible to cut any ordinary run of lumber entirely into 38 inch lengths. Similarly, if wide-rail stock is required, corresponding orders for narrow-spindle stock must be cut at the same time or the utilization of lumber will suffer. The grouping of orders to protect the utilization of the lumber is a matter which cannot be entirely covered by rules of procedure, but must be acquired by experience, and consultation with the foreman of the cutting department and the shop superintendent. In fact, the Order Clerk in beginning his duties should never send any orders into the plant without conferring with these individuals as to their practicability.

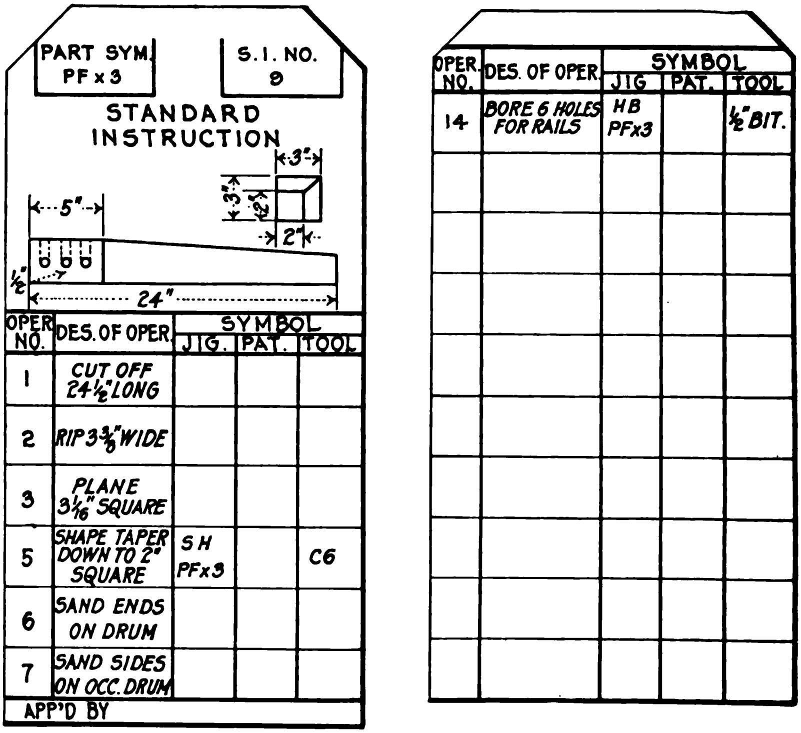
When the proper cutting assortment has been determined, the Order Clerk will attach to the part production orders on form shown in Figure 48 the proper order for the lumber as shown in Figures 24, 25, or 26, as the requirement is for kiln dried, green, or dimension stock.

Numbering of Orders

The manufacturing orders sent to the Planning Department by the main office should be numbered numerically. The production orders, however, should be numbered as follows: the assembly production orders as illustrated by Figure 49 will be numbered numerically followed by a dash and a serial numeral beginning with 1, indicating the number of assembly orders for that particular production order. For instance, the majority of production orders will have but one assembly number, but sho

manufacturing order require part to be manufactured of oak and part of birch, a separate production order will not be necessary for the two kinds of wood but the same number, followed by a dash and the serial numbers 1 and 2 will designate their individuality, but will allow them to be processed together, thus gaining the advantage of production manufacture.

Part production orders as illustrated by Figure 48 should



PART SYM. PF x 3 — S. I. NO. 9

STANDARD INSTRUCTION

OPER. NO.	DES. OF OPER.	SYMBOL JIG.	PAT.	TOOL
1	CUT OFF 24½" LONG			
2	RIP 3⅝" WIDE			
3	PLANE 3⁹⁄₁₆" SQUARE			
5	SHAPE TAPER DOWN TO 2" SQUARE	S H PFx3		C6
6	SAND ENDS ON DRUM			
7	SAND SIDES ON OCC. DRUM			

APP'D BY

OPER. NO.	DES. OF OPER.	SYMBOL JIG.	PAT.	TOOL
14	BORE 6 HOLES FOR RAILS	HB PFx3		½" BIT.

FIGURE 50.—Form for Standard Manufacturing Instruction

bear the same production order as the assembly production orders, and be followed by a dash and serial digits in the same manner. For instance, if production order number 500 requires twelve different parts to complete the unit, these parts will be manufactured on production orders 500-1 to 500-12 respectively.

This materially assists the stockkeeper in the machine stock room, as he realizes when he sees these numbers that these parts are to be immediately assembled into units and holds them in an accumulation space rather than putting them away in the bins. When parts are manufactured for stock alone, such serial digits

after the dash are not used, thus indicating to the stockkeeper that they are for stock and not for assembly, and hence may be put directly into stock.

Standard Instructions

As soon as the necessary production orders have been made out, the Order Clerk selects from his files the proper Standard Instructions to be attached to them. In woodworking, the standard instruction forms shown in Figures 50 and 51 have been found satisfactory. The standard instruction shown in Figure 50 is for use on individual parts. It is printed on tracing cloth and filled in in india ink from which blue prints may be made.

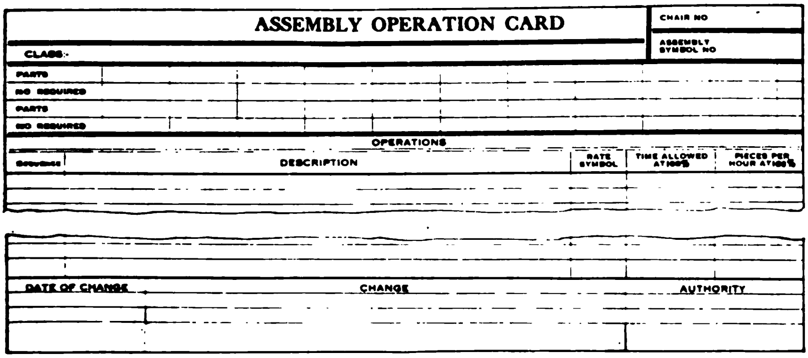


FIGURE 51.—Form for Standard Instruction for Assembling

The size and shape are such that the blueprints may be doubled and pasted over a standard shipping tag. This method allows a supply to be maintained at very little expense as these instructions are quite often lost in the shop. At the top of the instruction is shown a dimensioned sketch of the part and against each operation is shown the symbol of the jig, pattern, or tool to be used thereon. One of these should be attached to each part production order (Figure 48), giving the workmen the necessary technical information for performing their operations.

In Figure 51, is shown an operation card or standard instruction for assembly. These are maintained in two ways—a file of two copies of each may be maintained by the Order Clerk who will attach one to the assembly production order (Figure 49) before it is sent into the factory, retaining one copy in the file as a source of duplication in case the secor

shop. The preferable method, however, has been found in maintaining a file of these in the Planning Department with the Filing Clerk for reference or duplication purposes, and have another file maintained by the Assembly Foreman who supplies the workmen with these forms whenever necessary. It will be noted that this assembly standard instruction shows the parts used, a

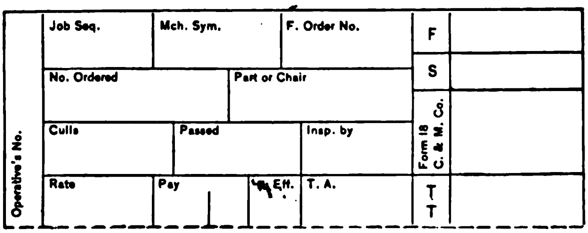


FIGURE 52.—Bonus Time Card

description of the various individual operations, the symbols for the corresponding bonus rates, and the time allowed for each operation. It has been found good practice to paste a photograph of the unit of product which it covers on the back of this form. The standard instructions shown in Figures 50 and 51 should

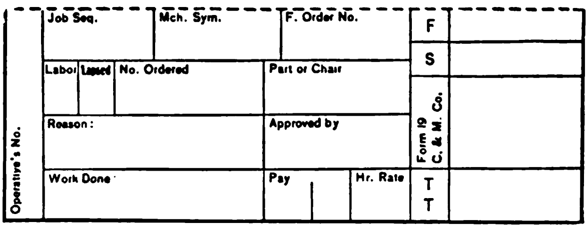


FIGURE 53.—Labor Time Card

supply to the workmen all the necessary information for the manufacture of the product not given on the production order.

JOB-TIME CARDS

Having selected and attached the standard instructions to the production orders, the Order clerk next makes out job-time cards for each operation shown on the production orders, showing on the time card the order number, operation symbol, symbol of machine on which operation is to be performed, symbol of the unit of product, estimated number of product, bonus rate under

which the work is to be carried on, and the time allowed. In Figures 52 and 53 are shown a form of time card which has been found very adaptable under the bonus plan used in woodworking factories, which will be described in Chapter X, under the subject of labor control. The form shown in Figure 52 is for recording bonus time; that in Figure 53 for recording labor or lapsed time. Occasionally, however, it has been found advisable to use one form for both purposes, in which case a form similar to that shown in Figure 54 is recommended. When the time cards have been completely made out, they will be attached to the

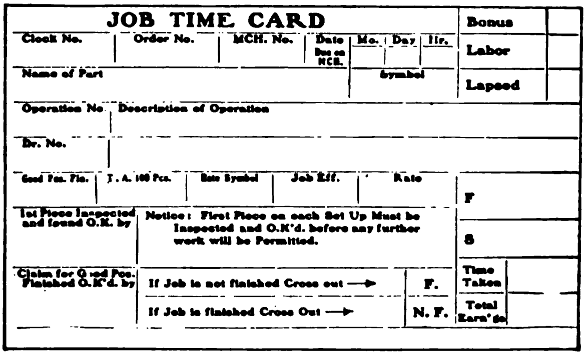

JOB TIME CARD
Bonus
Clock No. | Order No. | MCH. No. | Date Due on MCH. | Mo. | Day | Hr.
Labor
Name of Part | Symbol
Lapsed
Operation No. | Description of Operation
Dr. No.
Good Pcs. Fin. | T. A. 100 Pcs. | Rate Symbol | Job Eff. | Rate
F
1st Piece Inspected and found O.K. by
Notice: First Piece on each Set Up Must be Inspected and O.K'd. before any further work will be Permitted.
S
Claim for Good Pcs. Finished O.K'd. by
If Job is not finished Cross out → F.
If Job is finished Cross Out → N. F.
Time Taken
Total Earn'gs

FIGURE 54.—Form of Time Card Used With Bonus System of Wage Payment

proper production orders, and the entire group of production orders, lumber orders, standard instructions, and time cards turned over to the Stores Clerk who will make out requisitions for all materials required as shown by the layout sheet and attach these to the job-time cards covering the operations on which these materials will be used. The completed group of forms will then be given to the Schedule and Despatch Clerk.

SCHEDULING THE WORK

The Schedule and Despatch Clerk actually plans the work of the factory and issues the production orders, time cards, standard instructions, requisitions, etc., to the proper foremen in the factory. The mechanism of planning the work varies according to the size of the factory and the requirements of the management as well as the intricacy of the product.

Job Progress Board

In certain plants we have found a very simple production control board such as that shown in Figure 55 is sufficient. The principal of this board is to show the progress of the various part orders of each complete unit covered by a production order, through the various sections of the factory. The two top lines of large white buttons show respectively the factory order number and the number of part orders on the total order. The next five spaces represent the five manufacturing departments in this factory previous to assembly. Supposing that a certain factory order has twelve part orders. Its progress through the factory is indicated as the job-time cards are returned from the factory, showing the completion of individual jobs and are recorded by inserting a small white button with the number of the part on it; that is, in the example, from 1 to 12 in the proper position in the space representing the section of the factory wherein this particular part order has just been completed. When twelve such buttons are found in all sections previous to assembly, a large white button is placed in the seventh space from the top, indicating the number of assembly orders on the total production order, as in this particular factory the units were not assembled complete, but in certain sections. The progress of the orders through the balance of the factory is shown in the three

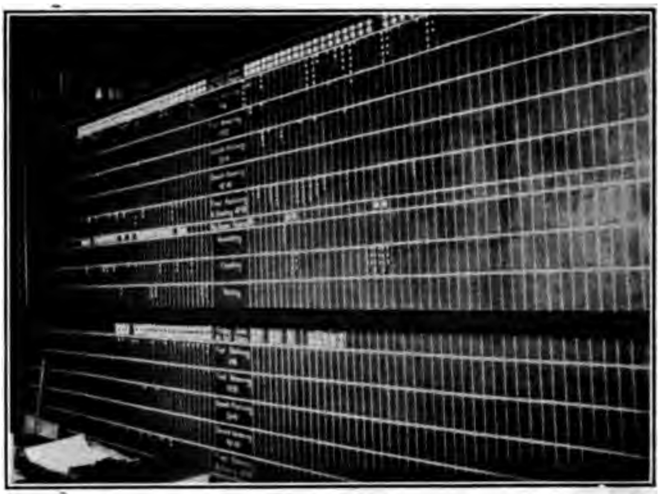


Figure 55.—A Simple Production Control Board

remaining spaces indicating assembling, finishing, and packing respectively, by a number of buttons equivalent to the number of assembly orders. This is a very simple control board, but it has proved very effectual in several cases as it allows the Schedule Clerk to constantly control the factory and to keep the individual buttons for the various part orders on each production order moving downward across the board progressively and evenly. This method, however, fails to give the actual control of manufacturing conditions which is obtained by the use of the board

FIGURE 56.—Another Form of Production Control Board

shown in the left-hand side of Figure 56. The details of this second board are better shown in Figure 57.

ORDER CONTROL BOARD

The order control board is composed of a backing of wood covered with a layer of cork preparation and painted black with white rulings. At the extreme left of the board is listed the departments to which the work is to be scheduled and controlled. At the right of each departmental division is listed the machine symbols of all the machines and work spaces in the department. It is against these machine symbols that the work is scheduled. Across the top of the board is also placed a list of the various departments and marked Orders Held At. The purpose of these divisions is to show in which departments work is being held up. This is done by placing the order number of work which is held up in a department on a small square of paper and

attaching it to the top of the board in its respective departmental division. Underneath the departmental division at the top of the board a space is provided for recording the working days of the month. At the beginning of each month, the number of calendar working days will be placed in these spaces. Each of these

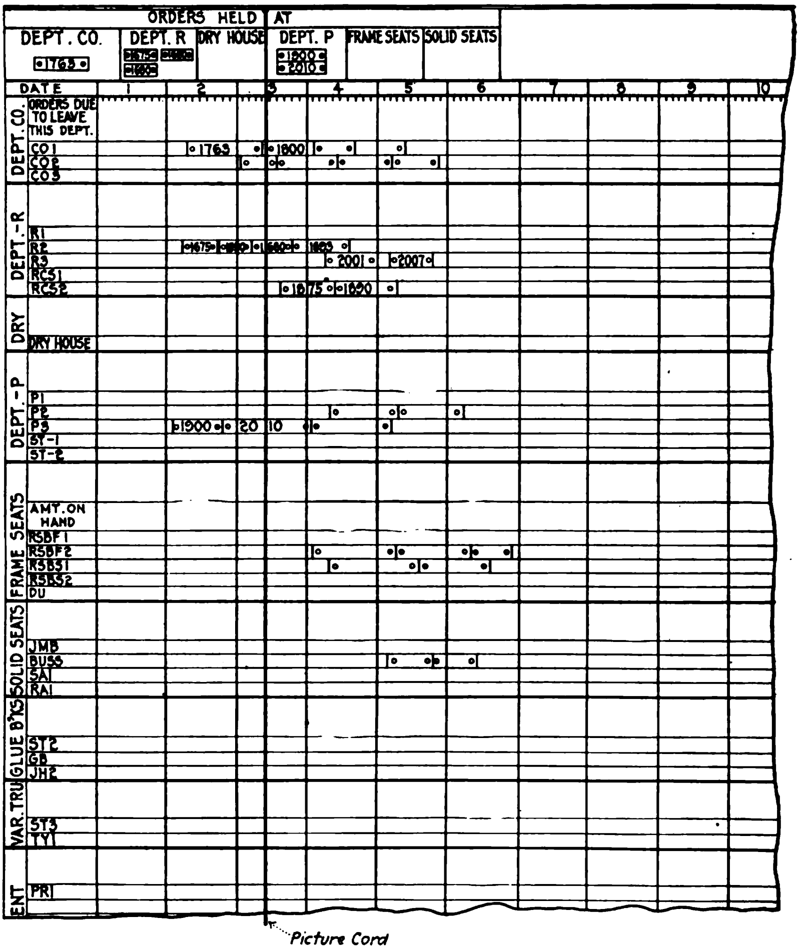


FIGURE 57.—Detail of Control Board Illustrated in Figure 56

divisions is subdivided into ten or less divisions to represent the working hours of the day. At the right of each departmental division, at the left end of the board, there is a horizontal column headed Orders Due to Leave This Department. In this column, under the date and hour that an order is due to leave the department a small square of paper is attached bearing the manu-

facturing order number. Across the top of the board is attached a rod from which a picture cord is hung with a small weight at the bottom to hold it in a vertical position. Each hour of the day the Process Clerk will move the cord along the rod directly over the division representing the hour of the day. All unfinished operations to the left of the cord will be behind schedule.

Operation of Control Board

When the job-time cards (Figures 52 or 54) are turned over to the Process Clerk for scheduling, the allowed time for performing each operation will be noted and a strip of schedule tape cut to represent the length of time required to perform the work and the order number written on the tape. The schedule tape will then be attached by means of thumb tacks to the board opposite the department and machine symbol, where the work is to be performed, this information being taken from the job-time cards. The right-hand edge of the schedule tape will be placed directly underneath the date and hour that the job is scheduled to be finished. The order number will also be placed on a small square of paper and attached to the board in the space headed Order Due to Leave This Department, under the day and hour that the order is scheduled to leave this department.

Assume that Figure 57 represents the condition of the control board at eleven o'clock on the third working day of the month. In Department CO only two machines have work scheduled to them, namely CO_1 and CO_2. Job number 1763 is behind schedule, also job numbers 1675 and 1690 in Department R and 1900 in Department P. As soon as these jobs get behind schedule, the Process Clerk will place a red thumb tack on the schedule tape and post the order at the top of the board under its respective department. When the job-time cards are returned to the Planning Department, showing that the operation has been finished, the schedule tape will be removed from the board. If the order scheduled is on time, the schedule tape will be held on by a yellow thumb tack; if behind the tack will be red; and if ahead of time, green. After the work has been scheduled, the job-time cards will be taken by the runner of the departments where the work is to be performed. If the order calls for work on shaped parts, the production order shown in Figure 48, together with standard instruction tags will be sent to the Storekeeper and

will serve as a requisition on him to deliver the parts called for to the department where the first operation is to be performed. The production order and the instruction tag will at all times remain with the work until it reaches the machined parts stores, but will then be returned to the Planning Department. The instruction tag will be filed for future use and the production order turned over to the Stores Clerk who will bring the stock records up to date. When the records show that all the parts for making the chair have reached machined stock, the Stores Clerk will

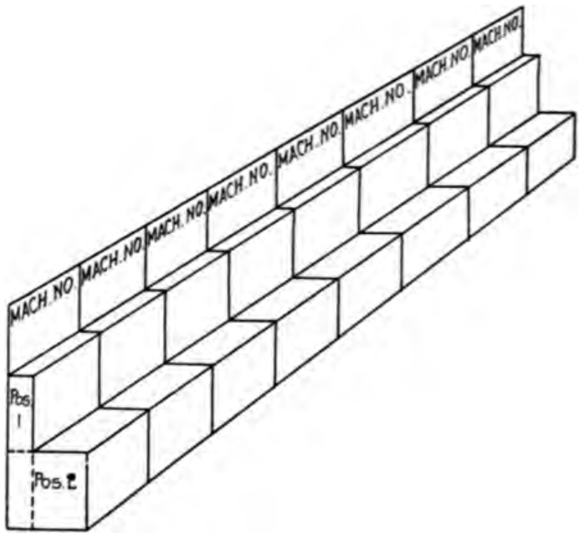


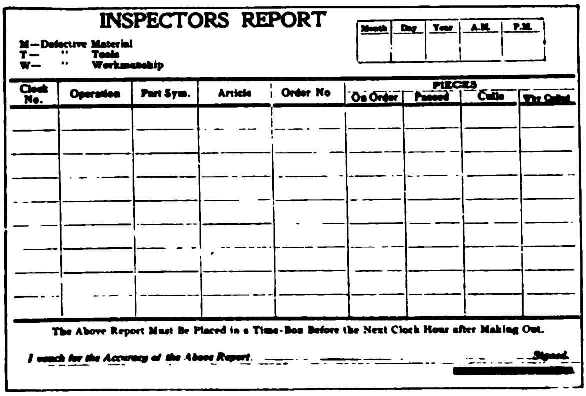
FIGURE 58.—Two-Position Job Time Card Rack

take the production order out of the Waiting for Parts to Reach Machined Stock tray and put it in the Orders to Be Assembled tray. The Process Clerk will then schedule the order on the assembly operations.

If the work is an assembly order, the assembly production order shown in Figure 49 together with the standard instruction will be sent to Machined Stores and serve as a requisition for machined parts to be delivered to the Assembly Department. When the parts are delivered, the storekeeper will send the assembly production order and instruction tag to the final inspector.

Routine of Handling Job Time Cards and Inspection

A two-position job-time card rack (Figure 58) will be placed at each foreman's desk. The rack will be so constructed that two positions will be provided for filing the job-time card for each machine and work space in the department. As soon as the various operations on an order are scheduled by the Process Clerk and the sequence in which the jobs are to be run indicated on the job-time cards by numerals placed in the Job Sequence space, the runner will take the job-time cards to the respective departments where the work will be performed, and file them in position 2 of



INSPECTORS REPORT

Month	Day	Year	A.M.	P.M.

M—Defective Material
T— " Tools
W— " Workmanship

Clock No.	Operation	Part Sym.	Article	Order No	Pieces On Order	Pieces Passed	Pieces Culls	Why Culled

The Above Report Must Be Placed in a Time-Box Before the Next Clock Hour after Making Out.

I vouch for the Accuracy of the Above Report. .... Signed.

FIGURE 59.—Form for Inspector's Daily Report

the card rack according to machine number and sequence in which the jobs will be performed. When the foreman is ready to start a job he will take the first job-time card from the front of the rack, place the operator's clock number on it, stamp it on the time clock for Start and place it in position 1 of the card rack. This will show the machines which are working and the work being performed on them. As soon as the operation has been finished the workman will report to the foreman and indicate the number of pieces he did on the job-time card. The foreman will stamp the card for Finish, place it in the time box and issue the next job to the workman. The foreman must issue jobs strictly according to their sequence. All job-time cards upon which work is being performed must be stamped out each night and turned into the Planning Department. This will be handled in the following manner: Just before quitting time, the inspector will

go to the job-time card rack and stamp the quitting hour on all job-time cards upon which work is being performed. He will be provided with a small rubber stamp for this purpose. He will then replace the cards taken from the rack with other cards bearing the same job symbol number, machine symbol, factory order number, part number, clock number, and starting hour for the next day. The inspector will also turn in each night an inspector's report (Figure 59) covering the work of each operator up to quitting time.

Inspection

The inspector or his assistants will inspect and count the work of each workman as soon as an operation is finished, enter the pieces passed and culled into the proper spaces on the production order and move the truck to the successive operation, and report to the Planning Department on an inspector's Report the information called for on the form. The report must be placed in the time box before the next clock hour after being made out.

Inspection for accuracy after all operations which effect the fitting of one part to another should be made by the use of simple steel plug, socket, or spanner gauges. This is a practice but little used in woodworking factories, but it more than pays for itself in avoiding the costly delays due to poor fits occasioned in the Assembly Department. The time and cost of such inspection can be greatly lessened by establishing inspections of the product just after a machine is set-up, and from time to time during the operation. The author has seen an inspector travel from machine to machine examining their product while operating, thus allowing him to safely pass the product without additional accuracy inspection.

At certain points between groups of operations the parts should be inspected by the eye, piece by piece, for wood faults, to prevent the expenditure of labor on pieces in which the wood has developed cracks or checks since the sawing, as of course, every piece is very carefully inspected for these wood faults immediately after cutting-off and ripping to avoid any useless machining.

The runner will collect the job-time cards and the piece counter's reports each hour of the day. He will take them to the Planning Department where he will copy from the inspector's report the pieces culled and passed and place this on the respective

job-time cards. The job-time cards will then go to the Process Clerk who will remove from the control board the schedule tape, corresponding to the operation.

FIGURING TIME CARDS

The job-time cards will then be turned over to the Time Clerk, who will figure the workman's pay. The bonus plan here referred to will be described at length under labor control in Chapter X. If the defective work is not to be paid for, the Time Clerk will only figure the bonus on the amount good, as shown on the job-time card, but if defective work is to be paid for bonus will be figured on the total quantity. The Time Clerk will now subtract the time started from the time stopped, as punched on the job-time card, and obtain the time taken for performing the operation. Time allowed will be divided by the time taken to get the per cent of efficiency the operator worked at and the amount of bonus determined from the direct-reading bonus calculating chart (Figure 60).

DIRECT-READING BONUS CHART

This chart is mounted on a firm backing with sliding ledge at the bottom. A 90-degree triangle slides along this ledge. Select the intersection between the hourly rate and hours worked, move edge of triangle to this point. Read directly up from the point where the triangle intersects the base line to the line indicating the per cent of efficiency. Move edge of triangle to this point and read money earned at point where triangle intersects base line. This chart can be mounted directly on the time clerk's desk and can be used by a fairly skilled clerk to figure time cards at the rate of 0.08 minute each. It automatically solves resolution of per cent of efficiency into per cent of bonus and (hours worked $\times$ hourly rate) + (bonus percentage $\times$ hours worked $\times$ hourly rate).

The author has found it preferable to the special slide-rule for efficiency and accuracy of operation.

WORKMEN'S RECORDS

At the end of each day all the times allowed and all the times taken are totaled and the average per cent efficiency obtained.

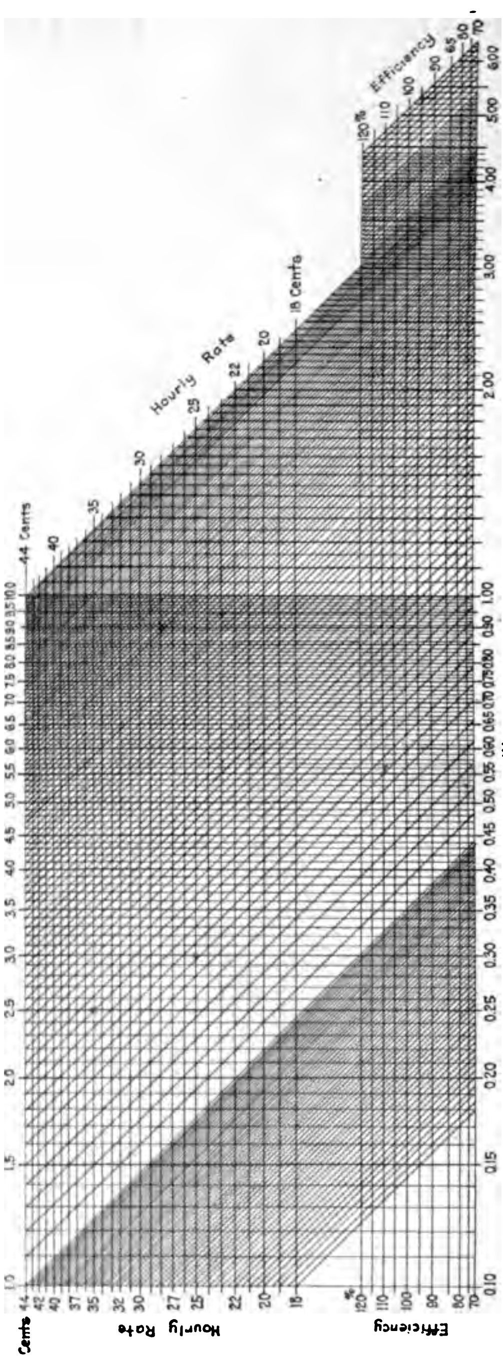


FIGURE 60.—Direct Reading Bonus Calculating Chart

This is entered on the workman's record (Figure 61) along with number of hours spent either on lapsed, labor or bonus, and the

FIGURE 61.—Form for Workmen's Personal Record

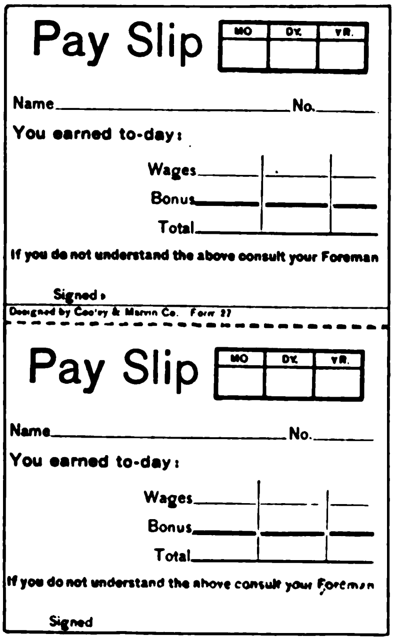


FIGURE 62.—Pay Slip Form

pay for these hours. At the end of the week these daily pays are totaled giving a weekly pay for each man. The payroll is

drawn off from this form each Monday. A pay slip (Figure 62) is given to all the men each morning, showing them the pay and the bonus they earned the day before, an important consideration in gaining their enthusiasm and co-operation.

Daily Labor Summary Sheet

After the pay slips (Figure 62) have been made out, they will be summarized daily on the daily labor summary sheet (Figure 63). This will be placed on the President's desk each day to

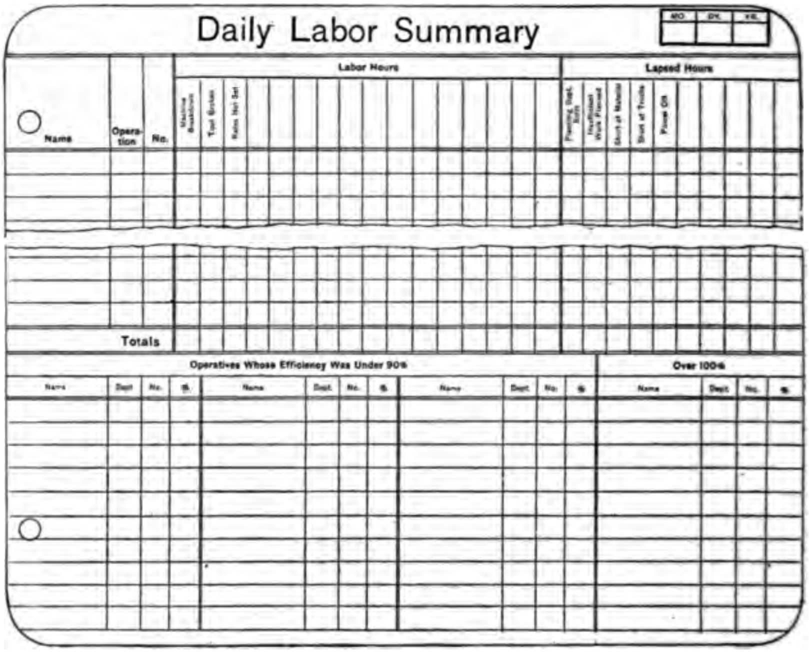


FIGURE 63.—Summary Sheet for Daily Report

show him the efficiency of labor in the plant. A carbon copy of this report should also be given to the Factory Superintendent in order that he may know what parts of the plant and operations need special attention.

From the job-time cards and material requisitions, all cost data is obtained and its accumulation is carried along together with these above described production functions, but the entire question of cost will be discussed later in Chapter XV, and therefore will not be considered at this time.

Operating Efficiency of Planning Department

The effectuality of a Planning Department is largely dependent not only upon the feasibility of the laying out of its functions to control the manufacturing processes, but due to the necessary intricacy of its functions, the mechanical operation of the Planning Department in itself must be given considerable attention or its operation will be more cumbersome than the in-

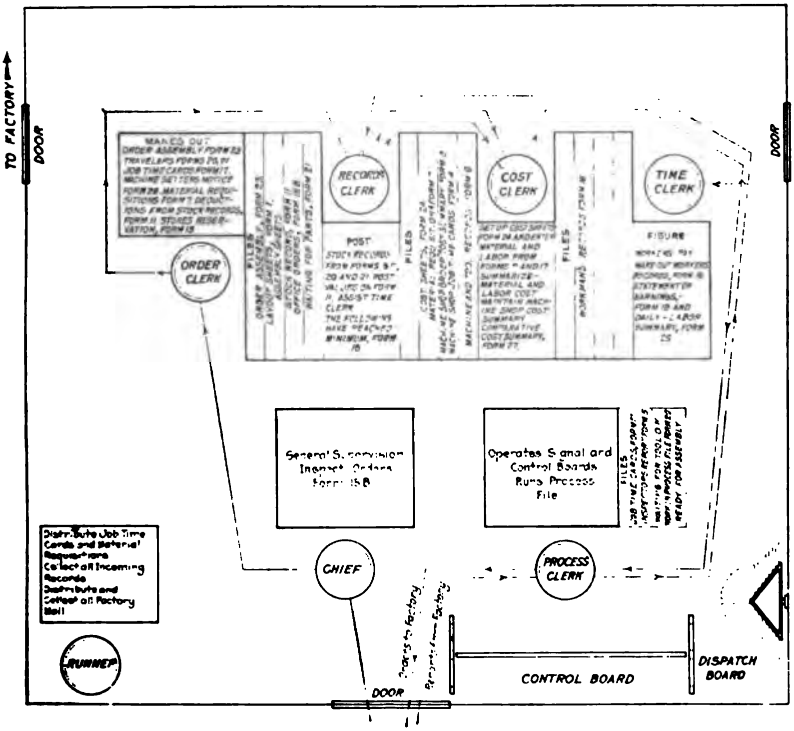


Figure 64.—Planning Department Chart

creased effectuality of the plant warrants. Therefore, as soon as the functions themselves have been devised, the next step should be to graphically lay out the functions of the Planning Department in chart form as shown in Figure 64. This enables the physical arrangement of the department to be created in accordance with the principles of correct routing and preventing needless backward and forward passing of records and moving about of the clerks. Furthermore, it shows graphically just what are the duties of each member of the personnel and provides for the accessibility of their desks and records.

Standardization of Clerical Work

Having provided the physical layout, next standard instructions for each member of the personnel should be written describing their duties very minutely, together with an estimate of the time required. The application of standards to clerical work is something which has not been recognized by the average observer of office routine, but the author has found it just as applicable as the application of standards to the operation of an automatic machine. For example, a clerk posting a perpetual

Mr.	DATE	SIGN HERE WHEN COMPLETED	DATE	SIGN HERE WHEN COMPLETED
DO FOLLOWING WORK UPON DATES GIVEN IN MARGIN TO RIGHT.				
REPORT TO MR. WHEN THIS HAS BEEN ATTENDED TO				

FIGURE 65.—Form for Daily Tickler for Organizing Engineer or Planning Chief

inventory can work very closely to standard. It can be determined within fairly close limits just how many times a card must be taken from a file and put back into the file with the respective times required, also the time for referring to a record such as a material requisition, making the entry on a special inventory card, the deduction and casting the balance. It has been the author's experience several times in investigating the duties of a clerk in a Planning Department where they claimed they were overburdened, to figure out with the clerk the actual time for making these various units of clerical work; to double the time accepted by the clerk as feasible, and then multiply this by the clerk's own estimate carefully determined of the number of times the various units are performed in a day, with a result

that the clerk who has before been overburdened by virtue of not thoroughly understanding just what his duties were and the proper manner in which to carry them out, has been able to not only perform his previous work satisfactorily, but to even take on considerable more duties while without this instruction he had been previously actually overburdened.

Such standard instructions should be made out for each individual in the Planning Department together with the proper standards and it should be the duty of the Planning Chief to insist that these standards be maintained in order that the routine of work may not fall behind. Furthermore, the author believes it is absolutely impossible to correctly estimate the number required in the personnel of a Planning Department without resorting to such standards of operation and time.

Tickler File

With the creation of the Planning Department a tickler file should also be instituted by the Planning Chief. As each point which apparently requires following up to keep it correctly functioning appears, either the Organizing Engineer or Planning Chief should make out a tickler form such as shown in Figure 65. This form should be printed on linen. In the Date column are notated the issuance dates, that is, the dates the tickler is to be issued from the files. A duplicate should be maintained which is inserted in a separate file when the original is issued, and the Planning Chief should trace the corresponding copies if they have not returned to the original file within three days after issuing. This provides an automatic following up for all the various matters which would otherwise be neglected.

With the detail of the organization finally perfected so far as possible until the physical changes are actually made, we will now consider the physical rearrangement of the plant.

CHAPTER VII

LAYOUT AND ROUTING OF THE PLANT

THE necessity for the re-routing of a plant lies in the fact that with a detailed control, definite standardization of each process is essential and all procedure must be orderly and systematic if the control is to function simply. Furthermore, a direct shortest route through a plant is the most economical manner in which to handle the product, not only from a direct consideration, but also from the fact that the shorter the distance it travels, the smaller will be the amount of stock necessary to carry in process and, therefore there will be a resultant reduction in capital invested in work in process. Furthermore, to develop standard manufacturing procedures certain specific routes of travel must be established, which must be adhered to in all manufacturing processes, and seldom are the conditions found in the average woodworking factory conducive to such definite systematic procedure.

The Routing Chart

The first consideration in the re-routing of a factory is the location of the lumber yard in relation to the incoming lumber and delivery to the factory. This subject was thoroughly covered together with a layout of yard, kilns, and stock sheds in Chapter IV, in the discussion of the storage and handling of lumber. After having determined the entry point for the raw material, consideration of the factory operations should be taken up. In this connection, the proper procedure is to refer to the classification and symbolization of product described in Chapter III, selecting from this classification prominent examples of all types or classes of product. The Works Manager and Superintendent should then be consulted as to the operations and their sequence required for manufacturing these items of product and the respective machines, benches, etc., upon which they are handled.

After the collection of this information, a routing chart similar to that shown in Figure 66 should be devised. It will be noted that at the top of this chart is shown the class of product, its description, the symbol or original name of the example used and the volume of its production during the previous year. With the list of operations in sequence furnished by the old management to manufacture these examples, the operations are then arranged at the left of the form in such a sequence that the majority of sequences for the examples under consideration is satisfied and to each of these operations is assigned an operational sequence number. In case a question of sequence comes up between which of two examples should be satisfied, give preference to the one with greater production.

Next to each operation is assigned a mnemonic operational symbol and finally, after assigning the equipment to each operation as designated by the original management, this equipment is assigned mnemonic symbols corresponding to the operational symbols with the necessary designating letters or numerals. For instance, supposing that for the second operation, as shown on Figure 66, there are two band rippers and two circular rippers. The symbol for the operation being R, designate the circular rippers by C, and the band rippers by B, followed by numerals indicating the individual machines. Such suffixed numerals should be used only to differentiate between practically similar individual machines.

Templet Drawings

Having laid out all the operations of the plant on charts, similar to that shown on Figure 66, scaled outlined drawings of each floor of each building should be made and properly notated. On these plans all permanent equipment such as elevators, stairways, etc., should be indicated. Then with thin cardboard, scaled cutouts should be made, using the same scale as the floor plans, showing the actual over-all dimensions of every article of equipment, such as machines, benches, racks, etc. In the case of machines, a red arrow should indicate the direction of flow of proucts through the machine, and a green arrow the direction of application of power. A small red cross should be placed on the side of the machine or bench at the point where the operator stands and a small red circle at each point where a helper stands. This allows the units of equipment to be placed upon the scaled draw-

ROUTING CHART - CUTTING AND MACHINING

OPERATION SEQUENCE	OPERATION	OPERATION SYMBOL	EQUIPMENT
[illegible]	[illegible]	[illegible]	[illegible]

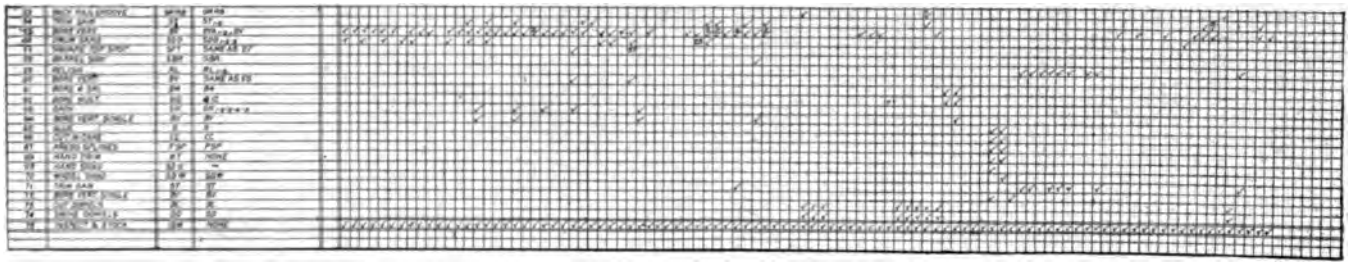


FIGURE 66.—Routing Chart for Cutting and Machining

ings and moved about until a satisfactory arrangement is found, the various symbols on the machines allowing the equipment to be set in its proper relation to supply, power, illumination, etc.

Transportation

After a tentative arrangement of the present equipment has been devised, the engineer should study the transportation of product through the factory, considering the various types of

Figure 67.—Confusion Due to Improper Use of Trucks

transporters to be used, designing, wherever possible, automatic conveyors, slides, chutes, etc., to transport the product mechanically.

The design of trucks alone requires considerable attention. With the varied product of the average furniture factory, to economically handle the parts between the various operations, avoiding unnecessary repiling and picking up spilled loads, requires a variety of trucks specially designed to fit the requirements of both product and operations. This, however, is seldom considered. The average chair factory for instance, aside from special trucks for seats, usually uses but one type of truck, whether 42 inch posts or 8 inch spindles are being moved. Often several small lots of different parts are placed on the same truck.

The usual results of such procedure are shown in Figures 67 and 68. The aisles and passageways should be carefully studied and special trucks designed when necessary with a view towards economically handling the material both from a transportation standpoint and from consideration for economical handling of the material into and out of the machinery. Consideration should also be given to the necessity for accumulation spaces between

FIGURE 68.—Another View Showing Unstandardized Truck Loading

operations of varying speeds. For instance, behind a very slow operation, unless the slowness of this operation can be overcome by increasing the equipment or effectuality of the operation, an accumulation space must be provided. Accumulation spaces must also be provided at points where several units of product come together for joint operations. For instance, a large accumulation space should be provided between the cut-off saws and the rip-saws for the reason that of necessity for the proper utilization of the lumber, a large number of orders must be put through the cut-off saws at the same time, while they travel through the rip saws one at a time, thus necessitating considerable sorting out and storage at this point. The location of the storerooms, offices, etc., must also be considered in relation to the effectuality of the layout.

STANDARDIZATION

At the same time the working out of the physical re-arrangement of the plant is under way, motion and time study, and investigation of the effectiveness of the individual processes should be carried on [illegible] of the family can be [illegible] [illegible] must be studied as noted [illegible] the best equipment [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

When all re-arrangements [illegible] have been [illegible] out in the [illegible] should be unit [illegible]

with small scaled blocks and sheets of wood, representing the relation of the various buildings, floors and equipment. The principal units of product should then be traced through this model by means of colored strings and any relation found unsatisfactory should be rectified.

FINAL PLANS

After the approval of such a model it can well be assumed that the problem has been given sufficient study, therefore the final drawings can now be prepared. These may be executed in one

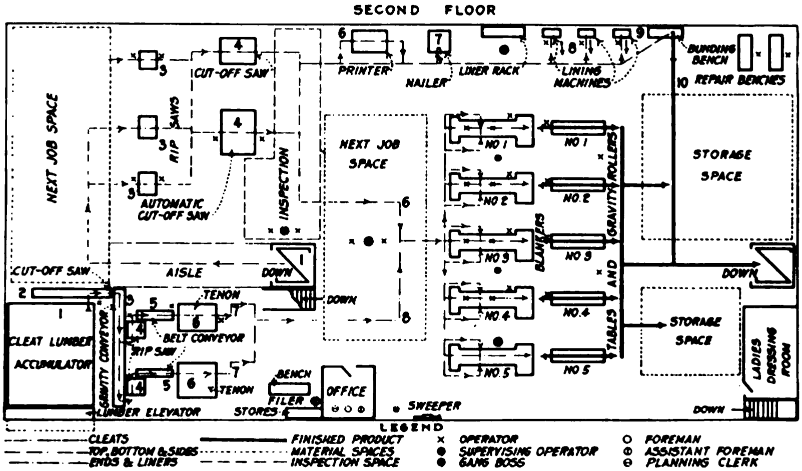


FIGURE 69.—Layout of a Floor of a Box Factory

or two manners as illustrated in Figures 69 and 70 respectively. Figure 69 shows a final layout of a floor in a woodworking plant (a box factory) where various types of lines and symbols indicate the flow of the product and location of the various types of the workers, while Figure 70 shows the use of a colored-line chart to illustrate the same facts in a chair factory.

For general illustrative purposes, a notated chart such as that shown in Figure 71 is sometimes valuable. This figure was prepared by the author and his associates illustrating the résumé of physical layout experience accumulated by their organization in the application of the principles outlined above in chair-manufacturing plants and presents several features which it is believed are effectual in this industry. The advantage of such a chart is that

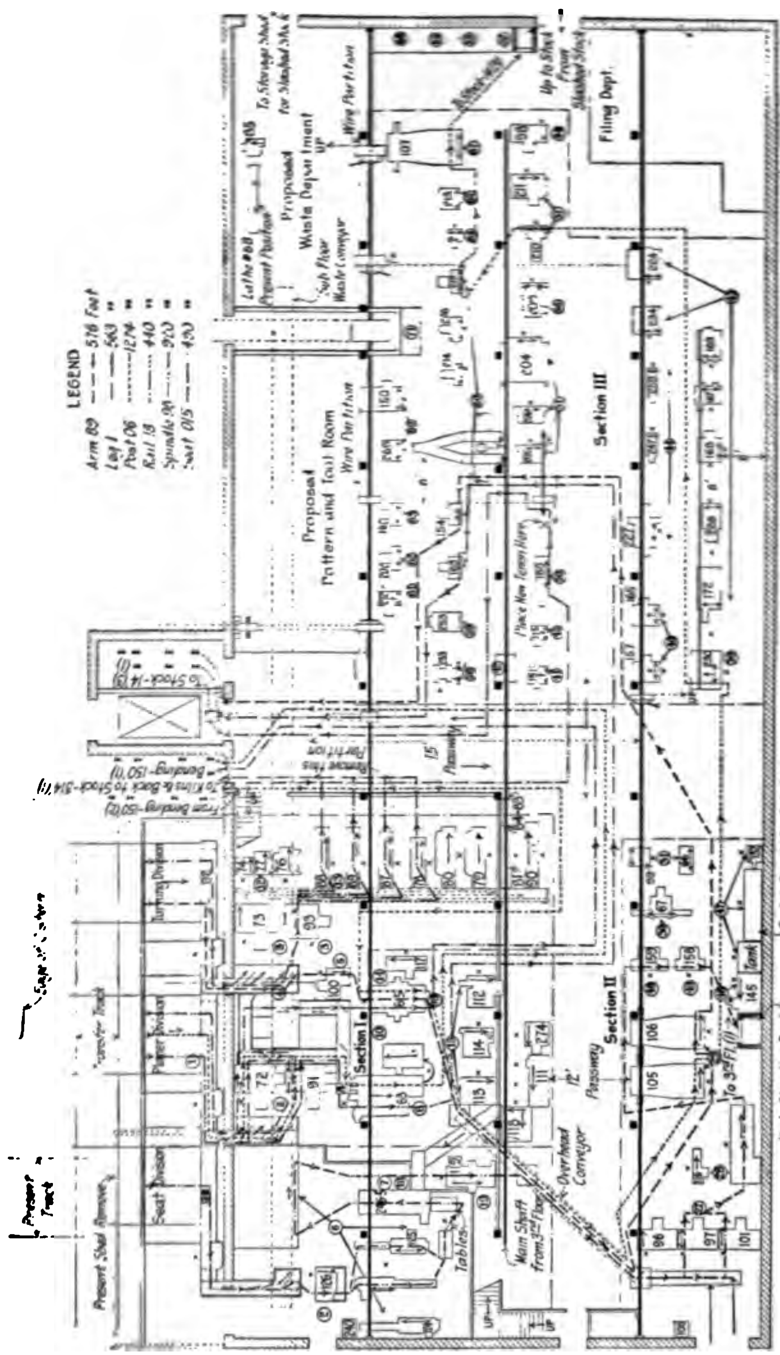


FIGURE 70.—Layout of a Floor in a Chair Factory

by a comparatively brief study, a grasp of the organization as well as of the physical layout may be obtained.

This illustration, Figure 71, is separated into three parts for the purpose of presentation. The first section shows the general layout of the first floor of the factory; the second the basement and second floor, and the third the upper or third floor. The following notes refer to seven special departments of which 1, 2, and 3 are indicated by corresponding numbers in the drawing of the main floor of Figure 71, and department 4 is directly across the building from department 2. The other three, 6, 7, and 8 are indicated on the second section of Figure 71.

1. Cut off Department.

Equipped with hydraulic elevators so that the Lumber may be kept at the level of the cut-off saw thereby increasing production through the elimination of fatigue. Cut-off saw has kick off device so that piece is placed on a conveyor belt and taken to sorter. Waste to be burnt is thrown into hoppers and by means of a belt conveyor, which travels under the floor, is taken to the boiler room.

2. Back Knife Lathe Turning Department.

Lathes are equipped with a waste conveyor that carries waste to boiler room. A reserve supply of green stock is kept in the basement. Lathes are equipped with counters so that the quantity turned may be noted on the labor ticket. Knives and all tools are kept in tool crib.

3. Frame Seat Department.

Stock is seasoned in basement and carried up by means of lift. At the same bench used for building up the frame seats are clamps used for gluing the blocks on posts and arms. A small hand jointer is placed near bench so that the blocks may be planed after gluing.

4. Wood Seat Department.

Seat is matched near trim saw, stock is then run through continuous jointer, placed in steam box, equipped with conveyor, so that the heat will open the pores of the wood, then passed over revolving glue brush and placed in rotary glue clamp.

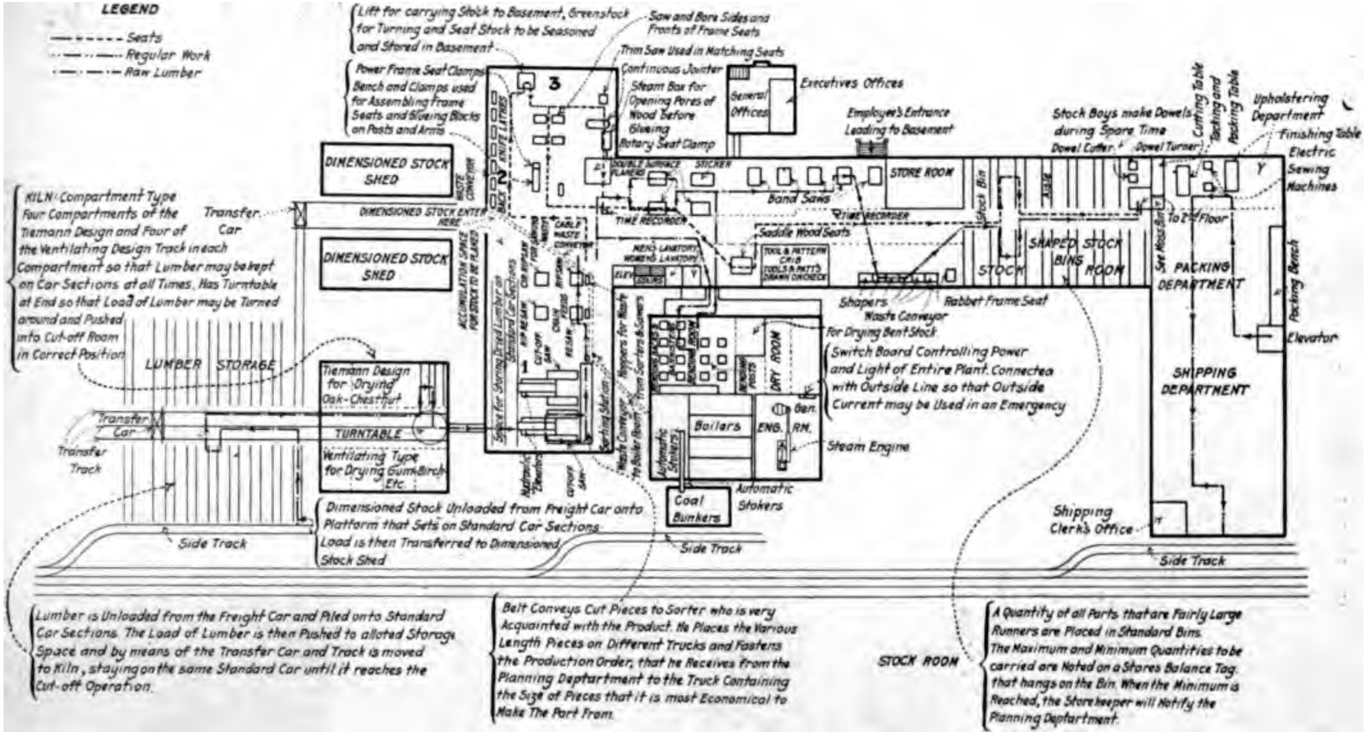


FIGURE 71.—Layout of the Departments of a Woodworking Factory With Notation

5. Seat Caning Department.

Cane is kept in stores room on first floor and delivered upon requisition by the foreman.

7. Sanding Department.

Work comes up on the elevator from shaped stock room, backs and bannisters follow along the left side of room while all straight work follows along the right side of the room.

8. Machining Department.

All machining operations except those necessary in driving up chair are performed in this department. Tools and patterns are kept in crib and are let out only on workmen's check.

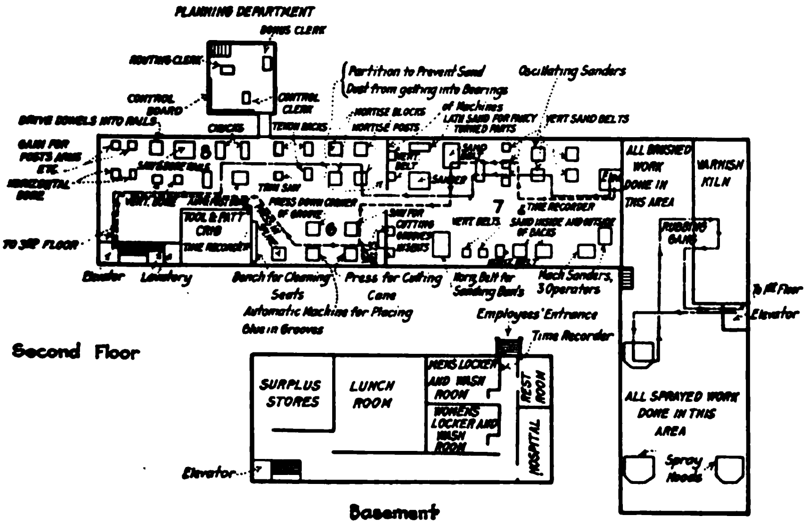


FIGURE 71—Continued

PLANNING DEPARTMENT FUNCTIONS

1. To route all work through the plant so that it will consume the shortest time and distance.

2. To plan all work for both the machines and men so that both will operate most efficiently.

3. To operate a wage payment method based on production so that it will serve as an incentive for greater production.

4. To keep a perpetual inventory of all lumber, chairs, chair parts, stores, etc.

5. To figure and record the actual cost of making each chair.

6. To maintain complete data as to how, when, and where to make each item of Product.

The Actual Physical Re-arrangement

After the proposed re-arrangement has been entirely worked out and detailed plans prepared, the re-organizing engineer should carefully schedule the actual carrying out of the re-organization work. For instance, if much machine movement is required, location space symbols should be worked up and the symbol assigned in advance as to which location each machine is to be

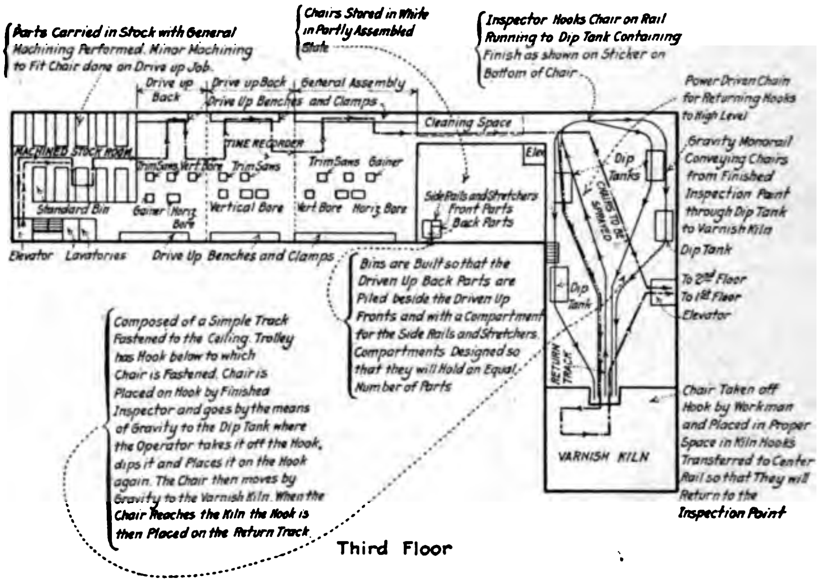


Figure 71—Continued

moved to. It is also important to definitely outline the exact order in which changes are to be made and to provide a progress chart to carefully check the carrying out of the schedules. A simple effective progress chart is to take a blue-line print of the proposed arrangement and as each item is placed in its correct location, outline this item on the print with a red pencil. Reference to the schedule and this print will show exactly how the schedule is being executed. An example of a schedule of re-arrangement is shown in the following pages, this being taken from the author's field instructions on an actual woodworking contract.

"SCHEDULE OF CONSTRUCTION WORK DURING SHUT-DOWN BEGINNING TUESDAY, DECEMBER 26, 1916

Superintendent

Clean out all possible stock and trucks from first floor

Furnish 4 helpers and 1 carpenter for the Blower Company from the regular employees of the factory

Install heating piping in new slasher shed

Re-line shafting after Building No. 2 has been raised

Furnish 3 men from factory to assist Graham in moving machinery

Furnish belt man and an assistant for putting on belts as soon as machinery is set

Arrange for machine shop to run to furnish necessary material for moving and setting up machinery.

Millwright

To be assisted by the following men: 3 helpers from factory, belt man, assistant from factory, millwrights Longberg and Miller, and carpenters Anderson, Daley, Cooley, Wicker, John Samuelson, Thompson.

On Tuesday and Wednesday, December 26 and 27, have millwrights and carpenters take down the following machinery, tagging every part of machine, shaft, pulley, belt shifters, etc., with

Machine Number	Location of Floor	Location Letter	Machine Number	Location of Floor	Location Letter
150	2	A	210	3	T
151	2	B	209	3	U
247	2	C	211	3	V
157	2	D	212	3	W
159	2	E	213	3	X
158	2	F	253	3	Y
163	2	G	215	3	Z
162	2	H	242	3	AA
164	2	I	230	3	BB
165	2	J	259	3	CC
168	2	K	228	3	DD
172	2	L	227	3	EE
169	2	M	226	3	FF
167	3	N	214	3	GG
202	3	O	234	3	HH
203	3	P	224	3	II
204	3	Q	180	3	JJ
205	3	R	269	3	KK
206	3	S			

a tag showing machine number and letter designating future location. All bolts, coach screws, nuts, washers, etc., for each machine, will be placed in a separate canvas bag which will be marked with machine number and securely tied to that machine. Jones with the 3 men from the factory will move all such machinery to the proper location as indicated on the blue print furnished him.

Beginning Thursday, December 28, all carpenters and millwrights will start erecting machines, first setting up those machines where the word Rush appears in red on the machine tag and blue print. During all the above work the new slashing machines will be completed, work being done upon them whenever material is available.

Machines 197, 98 and 115 are at present on the first floor and will simply be moved into new locations. The small sticker or moulder No. 85 and any small saws remaining on the first floor will be moved out of the way into the northeast corner of the first floor, where the waste department will be located.

Mr. Brown will endeavor to get all the machines outlined above from the second and third floors on to the first floor on December 26 and 27 as the elevators will not be available after that date for lowering machinery.

Mr. Brown will also move all sanding machinery from the second to the third floor after it has been taken down by Millwright's crew.

Millwright

Assisted by millwright Cody and carpenters St. Onge, Samuelson, Peters and Walker, and 2 new men.

On Tuesday and Wednesday, Dec. 26 and 27, they will remove all sanding machinery from the second floor. They will later loosen all sanding machines on third floor, moving them into proper position indicated on blue print.

This machinery will be taken to the third floor by Graham and the borrowed men from the factory.

Jones will see that the sanding machinery brought up by Millwright's men is placed in approximately the proper position as shown in his blue print. In removing machinery they will place all small material in canvas bags and tag all parts of machinery in same manner as outlined above.

Beginning Thursday, Dec. 28, Brown with his assistants will set all sanding machines on third floor.

General

If all the forces of both factory and construction gangs will work together harmoniously, rendering all possible assistance to one another, not simply endeavoring to accomplish their own work, interfering with one another, by January 8, that is, the date set for starting the factory, all machinery with the exception of the 25 odd machines used in connection with driving up on the third floor, will be set in position and the large majority will be belted ready to run. Also the new blower system will be connected with the machines which require it most.

Any changes in the above schedule are to be made only after the consent of both Mr. Bigelow and the Superintendent has been obtained, as it is their intention to work together in order that the greatest result may be obtained, not only in furthering the carrying out of the re-construction plan but also to have the factory in such condition that it may be operated on January 8."

CHAPTER VIII

SHOP PRACTICE AND STANDARDIZATION

THE usual method of cutting-off is illustrated in Figure 72. The lumber is brought into the factory on trucks and usually piled on the floor just behind the saw table. The operative

FIGURE 72.—Usual Method of Cutting Off Lumber in a Woodworking Shop

picks up the lumber, board by board, places it on the saw table and drags it by hand across the table, cutting it at the places he judges will most effectively utilize the lumber. He then distributes it, piece by piece, into adjacent trucks. The waste is usually thrown into a box or wheelbarrow standing near. This method requires extreme physical effort on the part of the operator, and also considerable judgment in utilizing the lumber to the best advantage. The operative usually has five or six lengths

furnished him which he can cut into various sizes with a more or less elastic limit as to the amounts of each. Examination of this method in a great number of factories throughout the country has shown that the average daily production for such work varies between 2500 and 3500 board feet per day for an operator and helper on each saw.

Considering this operation from the standpoint of scientific management it is evident that the most essential factor in the operation is the correct judgment on the part of the operator in

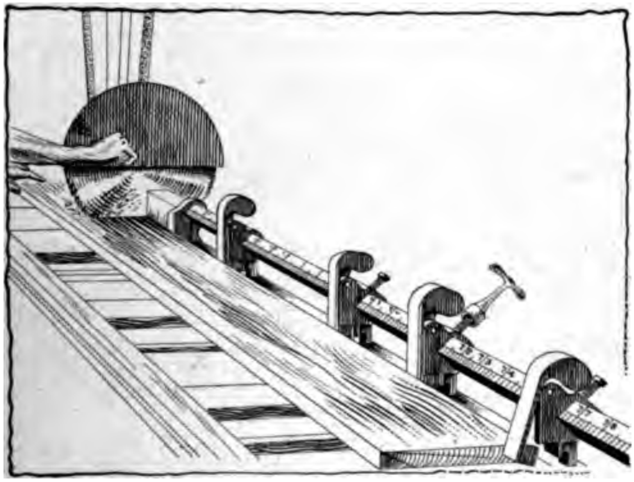


FIGURE 73.—Stop Gauge to Measure Length for Cutting Off

utilizing the lumber to the greatest possible advantage. We must, therefore, eliminate from the operator as far as possible the necessity for performing arduous physical labor, in order that he may be constantly in the proper physical and mental condition to exercise the necessary judgment. In working out this problem the idea of increasing the production was not considered as fundamental as increasing the utilization of the lumber, but strange to say the solution of the problem for one factor was very effective upon the other.

The procedure to eliminate the physical labor was to devise an arrangement whereby the lumber could be delivered upon and carried across the bed of the saw with practically no effort on the part of the operator. This was accomplished by installing a worm or hydraulic elevator upon which the load of lumber was run on tracks direct from the kilns or lumber yards, with the up-

ward travel of the lift so arranged that the top of the pile of lumber was maintained at a constant height of six inches above the bed of the saw table. By means of short steel skid-irons on the bed of the saw, running to the top of the pile of lumber, the operator, by seizing the end of a board, can with a single twist throw it onto the bed of the saw table. Power rolls are installed in the bed of the saw, controlled by a foot pedal, which allows

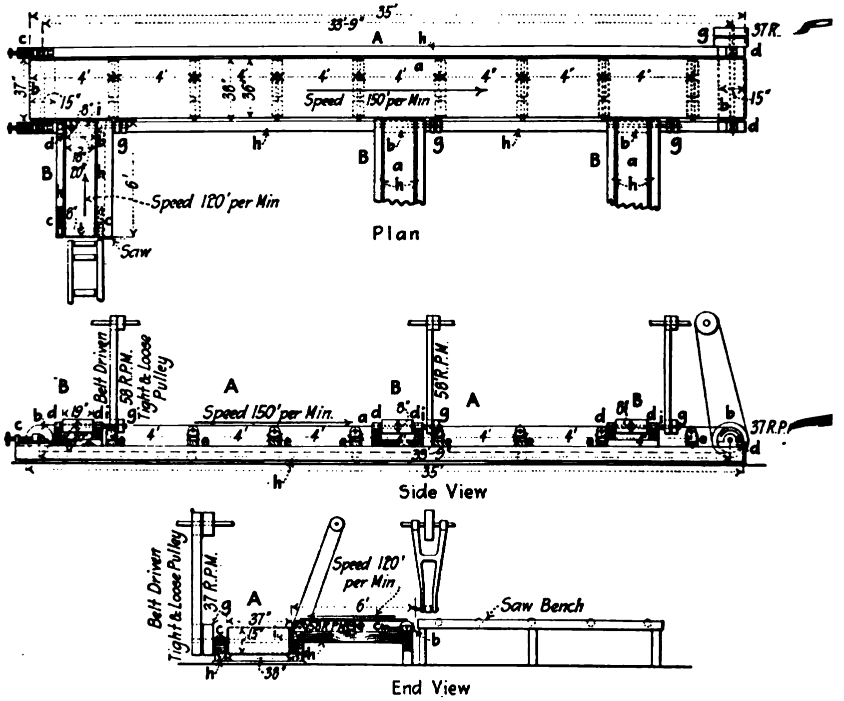


FIGURE 74.—Conveyors for Cut-off Saws

the operator to move the board across the table to any desired point by simply pressing his foot. The board is stopped at the proper place by a gauge which has several stops that can be set at the proper lengths ordered cut, the selection of this cutting assortment being outlined in Chapter VI. A simple pushing back of the board just before it reaches the proper gauge stops it at the proper point. This gauge is shown in Figure 73. As the saw returns to its normal position after the cut, a tilting device is automatically operated which throws the cut piece of board onto a short conveyor belt which carries it onto a distributor conveyor.

The design of these conveyors, which are constructed of canvas belting, is shown in Figure 74. In Figure 75, the cutting

FIGURE 75.—Cut-Off Saw With Gauge and Kick-Off Device

tion of two such saws is shown, indicating very clearly the ge and kick-off device which throws the cut lumber. Figure

URE 76.—Distributor Conveyor Handling the Product of Several Saws

shows the distributor conveyor onto which the short conyors deliver the product. This distributor conveyor is for the

purpose of collecting the product of several such saws, thus enabling the product of two or four machines to be sorted and piled by one or two sorters respectively. The arrangement of a group of these saws in this manner is shown in Figure 77.

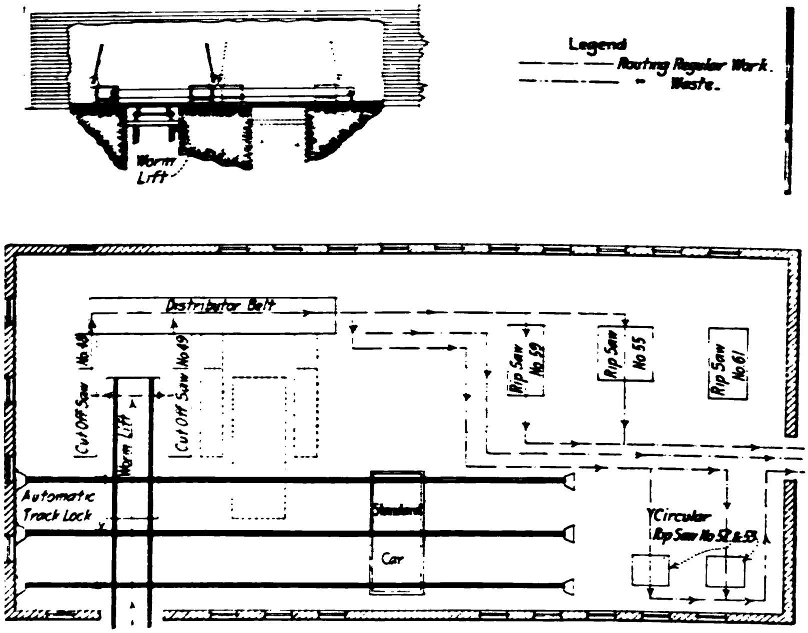


FIGURE 77.—Group Arrangement of Saws

TABLE 3—CUTTING TIME FOR VARIOUS LENGTHS AND WIDTHS OF LUMBER

A	B	C						D
		Cutting Time per Board Foot						
Length of Boards, Feet	No. of Pieces Cut	Width, Inches						Cutting Time per Lineal Foot
		4	5	6	7	8	9	
16	9	0.122	0.094	0.078	0.079	0.080	0.068	0.0430
14	9	0.120	....	0.086	0.072	0.079	....	0.0455
12	7	0.125	0.111	0.095	0.089	0.078	....	0.0473
10	7	0.100	0.107	0.101	....	0.094	....	0.0465

To determine the production on these machines a basis was required which would allow for the automatic collection of production data which would fairly reflect the effectuality of the operative. Considerable time study resulted in the determination that the lineal feet of travel across the bed of the saw was a constant under practically all conditions. Table 3 shows this fact in times determined by actual time study.

Comparison of columns A and B show that there is little relation between the length of boards and the number of pieces cut. This is to be expected, as the utility of cutting depends upon the grade of lumber, and therefore, there can be no definite relation between the number of cuts and product of the operation, as the length of the pieces cut will never be constant.

Inspection of column C shows that there is a variation of 53.4 per cent in the time required for cutting a board foot which

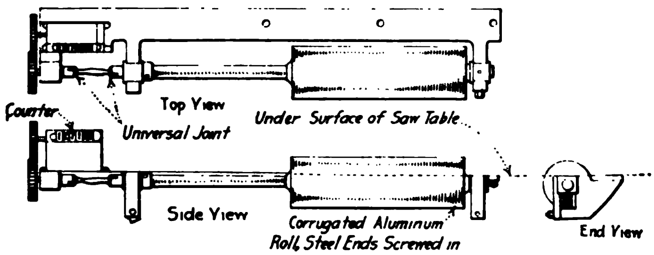


FIGURE 78.—Counting Device for Lineal Footage

is principally due to the effect of width. This in itself indicates that length is a more constant factor, as the effect of width is so marked upon the results of the board foot basis. For instance, note in column C that a 16 foot board 4 inches wide requires 0.122 minute per board foot, while a board 16 feet long and 8 inches wide requires 0.080 minute per board foot; that is, it requires but two-thirds as much time to cut a board foot in a board 8 inches wide as it does in a board 4 inches wide, while there is actually twice the board footage of product in an 8 inch board as there is in a 4 inch board.

Inspection of column D, however, shows but 9.1 per cent variation in the cutting time per lineal foot in boards 10, 12, 14, and 16 feet long and in 4, 5, 6, 7, 8, and 9 inches wide. In other words, lineal footage is clearly demonstrated to be the easiest determined constant factor in cutting varying sizes of lumber. It

might be mentioned that considerable time study has demonstrated that the thickness of lumber has very little influence on the cutting time, if the saws are properly filed and driven. Of course, if the power of the saws is not sufficient to easily cut through the thickest lumber handled, a retarding effect would be noticed when handling the thicker grades of stock.

A counting device which is not susceptible to easy falsification on the part of the operator and which collects information as to the lineal footage handled is illustrated in Figure 78. This device consists of a floating roll which is set into the bed of the saw. It can be plainly seen in Figure 75 at each side of the oil can in the foreground.

As stated above, the average production under the old arrangement of cutting off was approximately from 2500 to 3500 board feet per day. The time allowance for operating one of the saws described as used on several different installations is as follows: for cutting 100 lineal feet and removing the cross sticks between the piles of lumber 0.092 hour and for cutting 100 lineal feet without removing cross sticks 0.08 hour. The usual practice is to have the saws so arranged that two operators can cut off the same pile of lumber, thus making one elevator sufficient for each two saws. One operator is required to remove all the cross sticks, thus allowing him to work under the first rate while the other does not remove cross sticks and works under the second rate. These rates indicate that in a ten-hour day, which until recently has been prevalent in the majority of woodworking factories, a workman can cut around 12,000 lineal feet, or approximately 7500 board feet. Furthermore, with the old method a helper was required for each operator while with this method a helper is sufficient for each two saws, these helpers acting as sorters at the end of the distributor conveyor. In other words, two operators and one helper can cut 15,000 board feet of lumber per day, while with the usual method two operators and two helpers can cut but 5000 to 7000 feet.

Furthermore, these operators have to exert far less effort to maintain this production than is required by the old methods, inasmuch as there is very little physical exertion required. The operator is in a much better condition to use his judgment in properly cutting the lumber, which results in a more effectual utilization of the lumber. Therefore, strange as it may seem, both quality and quantity are improved by this method. Considering this matter, however, from the fundamentals of scientific

management, it is to be expected. Invariably, when physical effort is removed and a standard method of operation provided, no matter how much the resultant production may be increased, the quality of the product is materially improved.

Practically the same results have also been obtained by equipping the carrier rolls of the saw table with ball bearings in place of applying power. This method has also been used for both swing and undercut saws with practically the same result, the essential factor being to remove the physical exertion of the operator in handling the lumber.

Rip Sawing

This operation is comparatively simple, consisting of ripping the cut-off pieces of lumber into the required widths. It is divided into two classes, straight ripping and utility ripping. By straight ripping is meant taking the cut-off pieces of stock and passing them through the rip saw, cutting as many pieces of a definite size as possible out of the stock, while by utility ripping is meant the cutting of various sized pieces out of the stock, avoiding defects in the lumber and thus utilizing the lumber as far as possible to obtain perfect pieces. Naturally the latter requires considerable more time than the former. The time also increases materially as the length of the stock increases, inasmuch as it requires not only a different amount of sawing time, but that the passing back of the stock to the sawyer by the helper requires more time than when shorter stock is required. The operation of a rip saw and the time required are described in the following bonus rate with its accompanying Figure 79.

Bonus Rate for Rip Sawing

Work Handled Under This Rate

Sawing to edge the stock and sizing.

Data

Machine Maker—F. A. Cheney, Boston, Mass.
Feet saw runs per minute = 8100.

Description of Present Condition

The supplying is done correctly. Operator changes his own saws and takes dull saws to machine shop to be sharpened.

Recommendations for Standardization of Condition

Supplying will be taken care of by the department supply man. Machine setter for this department will take care of all saws, change and set machines. Sweeper for this department will take care of all the waste from the saws and keep the trucks for the waste emptied.

Machine will always be supplied with three trucks: one for finished stock, one for waste and one to hold odd sizes that will

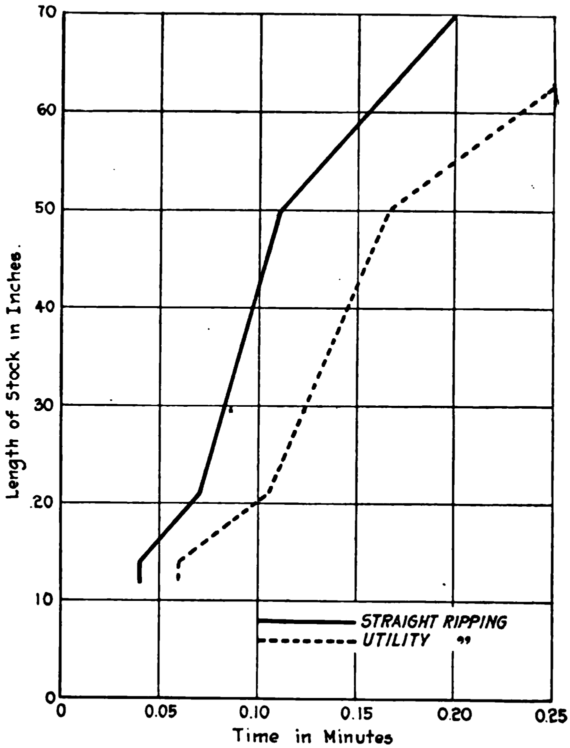


FIGURE 79.—Time Required to Cut Different Lengths of Stock

go to a bench where some of the small parts are cut out of these pieces.

Addendum A (Figure 79) shows the time in minutes required to cut different lengths of stock. About one-half of the cuts made by saw are to cut waste.

When finding time to saw one piece or cut, we have taken into consideration the amount of cuts that have to be taken that cut waste for a total of 100 pieces. Piece time also includes time

for taking pieces from truck and piling finished pieces back on truck.

Saws are operated by two men; the man that operates the saw and one helper that piles the stock on a truck after it is sawed, and who also back passes long stock.

Analysis

Addendum A (Figure 79) shows two curves; one straight ripping and the other for utility ripping, by this we mean where operator is obliged to inspect every piece before he saws it.

A = Length of piece
B = Time to saw one piece (See Figure 79)
z = Allowance for rest or fatigue. 15 per cent
t = Actual time to do 100 pieces
T = Time allowed for 100 pieces in hours

Synthesis

$$t = B \times 100 = 100B$$

$$T = \frac{100B \times 100z}{60} = \frac{100B \times 1.15}{60}$$

$$= \frac{115B}{60} = \text{hours per 100 pieces stock}$$

Example: Take pieces cut 30 inches long, chart shows time for one piece 30 inches is 0.085 minute.

B = 0.085 minute
$t = 0.085 \times 100 = 8.5$ minutes

$$T = \frac{8.5 \times 1.15}{60} = 9.8 \text{ minutes or } 0.0163 \text{ hour per 100 pieces}$$

Rip Saw With Return Conveyor

Where a great deal of returning of partially cut pieces by the tailer to the sawyer is found necessary in ripping, a specially designed saw such as is illustrated in Figure 79-A is an excellent investment. This saw is equipped with a sectional feed roll such as is used on planers and a return conveyor (canvas belt type) which allows the sawyer and tailer to work double handed to great advantage. An increase of 50 per cent in production can easily be anticipated using this method in place of hand passing on stock of any length.

Band Sawing and Shaping

Band sawing is an operation requiring considerable training and is regarded in most factories as a trade requiring considerable experience and skill. Its standardization is seldom attempted, the setting of rates even being left in a great many cases to the operator himself. This operation may be standardized, however, as is proven by the successful installation of bonus rates based upon time study, an example of which is shown in the following rate which was successfully installed on this operation.

The shaping of furniture parts, toys, etc., on spindle shapers commonly known as the "shaping operation" is very similar to

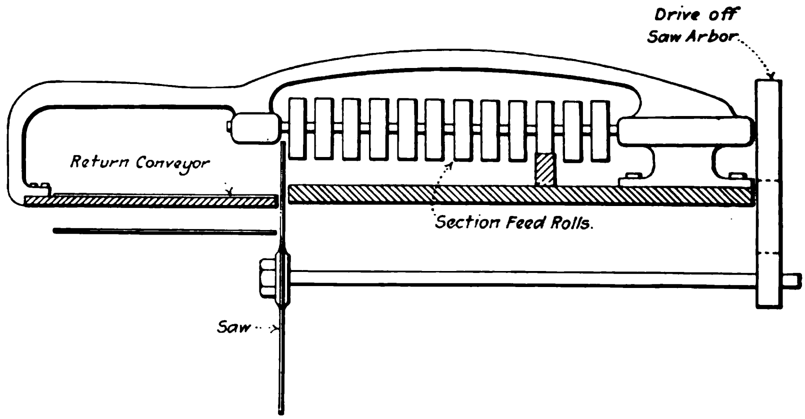


Figure 79-A.—Return Conveyor Attachment for Rip Saw

band-sawing in its conditions and difficulty of rate setting, fundamental rates, however, such as that shown below for band sawing may be applied to shaping with success. Table 5 shows time required to shape various lengths.

Bonus Rate for Band Sawing

Rate Symbols

Setting—15-SBs
Operating—15-SB

Time Allowed

Setting—15 minutes = 0.25 hour per setting
Operating—See Table 4

Work Handled Under This Rate

Sawing stock of various lengths and thicknesses into various shapes; mostly backs, banisters, legs, and saw handles.

Data

Maker of machine—Unknown
Operators—American and French—Good
Number of feet saws travel per minute = 4534.

Description of Present Conditions

Some of this work is done on day work, the major part, however, being job work.

Supplying is very poor and operator changes his own saws.

Changing saws consists of taking saw off, taking it to the machine shop and bringing back a sharp saw, putting it on and setting the machine.

Recommendations for Standardization of Conditions

Under standard conditions the supply man will supply these machines and take away the finished stock.

Machine setter will change all saws and a boy will do all the marking of patterns for this floor on bonus.

Some classes of work will have to be handled twice because two grades of saws will have to be used. One machine will saw what it can with one grade of saw and this order will be pushed to next machine with the fine saw. An example for this kind of work is arm Am56.

Analysis

A = Time to pick up one piece = 0.05 minute
B = Time to move to saw = 0.03 minute
C = Time to sow waste = 0.08 minute
D = Time to saw each corner clean = 0.06 minute
E = Time to saw (See Table 4)
F = Time to saw waste = 0.08 minute
z = Allowance for rest or fatigue = 15 per cent
t = Actual time in minutes per 100 pieces
T = Time allowed per 100 pieces in hours

Table 4 shows time for straight cutting (curves with a radius over 3 inch considered straight). Time allowed for curves with a radius of 1 inch to 3 inches is also shown on chart. The chart shows time for cutting different lengths under 1 inch in thickness and over 1 inch in thickness. Special on chart shows allowance where operator is obliged to use jig.

Synthesis

$$
\begin{aligned}
t &= (A+B+C+D+E+F)\times 100\\
&= (0.05+0.03+0.08+0.06+E+0.08)\times 100\\
&= (0.03+E)\times 100\\
&= 1.3+100E\\
T &= \frac{t\times 100z}{60} = \frac{t\times 1.15}{60}\\
&= \frac{(13+100E)\times 1.15}{60} = \frac{14.95+(100E\times 1.15)}{60}\\
&= \frac{14.95+115E}{60} \text{ hours per 100 pieces}
\end{aligned}
$$

It is the custom on some patterns to nail two pieces together. In cases like this, time should be divided by two.

TABLE 4—TIME REQUIRED TO CUT WITH BAND SAW VARIOUS LENGTHS AND THICKNESSES OF LUMBER (SYMBOL SB)
(All Values are Given in Minutes)

Length of Piece in Inches	Straight Cutting		Curve Cutting					
	Thickness		Thickness Under 1 Inch			Thickness Over 1 Inch		
			Radii			Radii		
	Under 1 Inch	Over 1 Inch	1 Inch	2 Inch	3 Inch	1 Inch	2 Inch	3 Inch
2	0.06	0.07	0.08	0.06	0.06	0.11	0.10	0.08
4	0.08	0.09	0.25	0.15	0.13	0.35	0.25	0.20
6	0.08	0.09						
8	0.09	0.11						
10	0.09	0.11						
12	0.10	0.13						
14	0.10	0.13						
16	0.11	0.15						
18	0.11	0.15						
20	0.12	0.17						
22	0.12	0.17						
24	0.13	0.21						
26	0.13	0.21						
28	0.14	0.25						
30	0.14	0.25						
32	0.15	0.28						
34	0.15	0.28						
36	0.16	0.30						
38	0.16	0.30						
40	0.17	0.32						
42	0.17	0.32						

Allow 0.04 minute to pick up one piece from truck.
Allow 0.03 minute to move piece to saw.
Allow 0.08 minute to saw waste.
Allow 0.03 minute to place piece on truck.
Allow 0.06 minute to saw corner clean.
Special—allow 0.12 minute to place piece in jig.
Allow 0.08 minute to take piece out of jig.

TABLE 5—TIME REQUIRED TO SHAPE VARIOUS LENGTHS OF LUMBER (SYMBOLS SH)

(All Values are Given in Minutes)

Length of Surface in Inches	Under 1¼ Inches Thickness Straight	Over 1¼ Inches Thickness Straight	Length of Surface in Inches	Under 1¼ Inches Thickness Straight	Over 1¼ Inches Thickness Straight
2	0.03	0.04	24	0.08	0.09
4	0.03	0.04	26	0.09	0.10
6	0.04	0.05	28	0.09	0.10
8	0.04	0.05	30	0.10	0.11
10	0.05	0.06	32	0.10	0.11
12	0.05	0.06	34	0.11	0.12
14	0.06	0.07	36	0.11	0.12
16	0.06	0.07	38	0.12	0.13
18	0.07	0.08	40	0.12	0.13
20	0.07	0.08	42	0.12	0.13
22	0.08	0.09			

Allow 0.04 minute to pick up one piece.
Allow 0.10 minute to clasp one piece in jig.
Allow 0.05 minute to take one piece out of jig.
Allow 0.03 minute to lay one piece on truck.

SEAT, PANEL, OR SLAB MAKING

The gluing up of wood to make furniture parts, such as seats for chairs, slabs or panels for table tops, is an important operation in furniture manufacture. It is difficult to obtain secure joints, without careful control of influencing conditions, and in the effort to obtain secure joints efficiency of operation is often neglected. In several chair plants seats are still made by gluing the edges of the boards by hand and clamping the seats in hand clamps. The production is from 200 to 300 seats per day.

Figure 80 shows an arrangement of equipment, which, if properly operated, tongue-joints, matches, glues-up and clamps

from 700 to 1000 seats per day with two operatives or twice that number with four operatives.

The positions for the two operatives are illustrated by A and B respectively. The equipment shown is as follows:

1 Continuous tongue-jointer
2 Bin for product from jointer
3 Matching table
4 Conveyor operated heater
5 Glue rolls—power
6 Continuous clamp

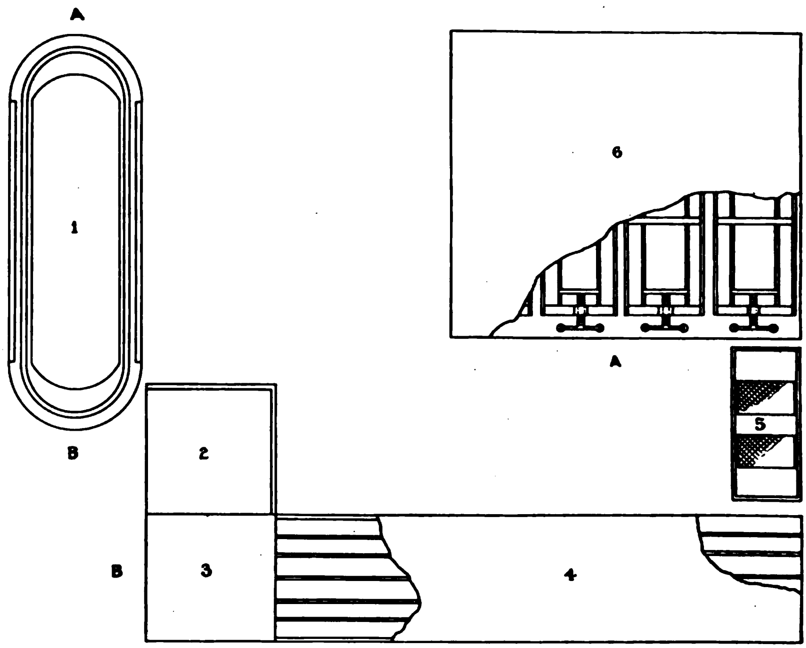


FIGURE 80.—Gluing and Clamping Device for Chair Seats

The two operatives first operate the continuous jointer (1) filling bin (2). B then matches up seats on table (3) placing them in heater (4). A takes them from the opposite end of 4, passes them over glue-rolls (5) and clamps them up in (6) removing a dried seat and placing it in a truck just before putting a freshly glued seat into the clamp.

When a greater production is desired, four operatives may be used instead of A and B, each performing two different operations in cycles.

The quality of the seats is protected by proper preliminary

heating in (4) and the boxing-in and heating of (6) to a comparatively high temperature (often 100 degrees Fahrenheit) during the time of drying.

The speed of the operation is limited by the drying time in the clamp, therefore, the following bonus rate will serve as a standard for the complete operation.

Bonus Rate for Gluing and Drying on Solid Seats

Rate Symbols

Gum birch and oak seats, 3 joints—GGD-1
Maple seats, 4 joints—GGD-2
Chestnut seats, 8 joints—GGD-3.

Time Allowed

GGD-1-Operating—39 minutes or 0.65 hour per 100 seats.
GGD-2-Operating—42 minutes or 0.70 hour per 100 seats.
GGD-3-Operating—104 minutes or 1.73 hour per 100 seats.

Work Handled Under This Rate

Pieces of stock of various lengths, widths and thicknesses (and different kinds of wood) are glued together to various sizes (in the rough) from which seats for chairs are cut out.

Data

Gluing Machine Makers—Chas. E. Francis Co., Rushville, Ind.

Clamping Machine Makers—Unknown.

Both machines are worked by operator and no other power used.

Description of Present Condition

Stock is taken from drying box and edges are glued. Then stock is placed in a clamp in the glue-drying machine. The drying machine is turned by hand and the gluing machine is worked by operator's foot. Working gluing by the foot is a tedious job and should be stopped. Machine is also too long and a machine one-half as long would have answered for all classes of work.

Recommendations for Standardization of Conditions

The stock is supplied as well as it can be with the present machinery and location. Finished seats are trucked away.

Gluing machine will be run by power, which will mean a great deal to operative in 10-hours' work. The heat in this department on a hot day is too high. A fan should be installed to eliminate this.

On account of the joints on some of the seats coming apart, the inspection in this department should be very rigid. Bonus rate has been made liberal for this reason . This work is done

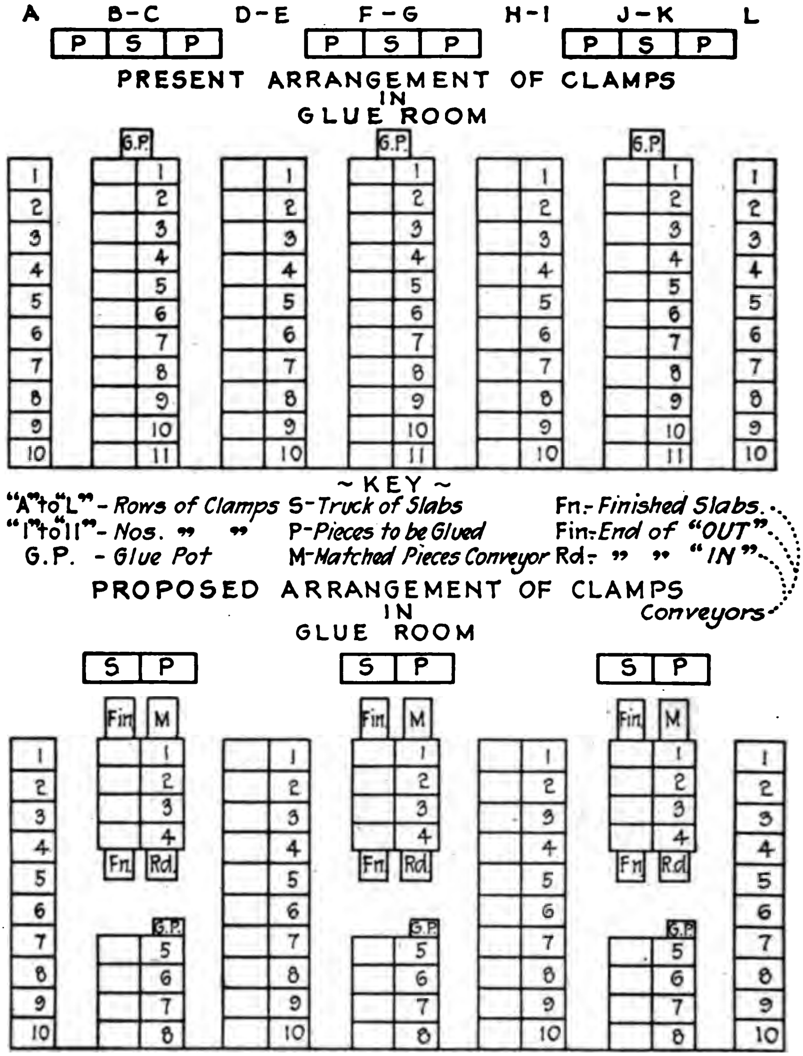


FIGURE 81.—Observed and Proposed Arrangement of Clamps in Glue Room

by two men but as the number of seats they are obliged to make every day is not very high, we believe one man should do this work. We believe the fairest way to pay bonus on this work will be figured so much per joint. The analysis will show how we obtained time per joint.

Analysis

A = Time to pick up one piece and place in clamp = 0.04 minute

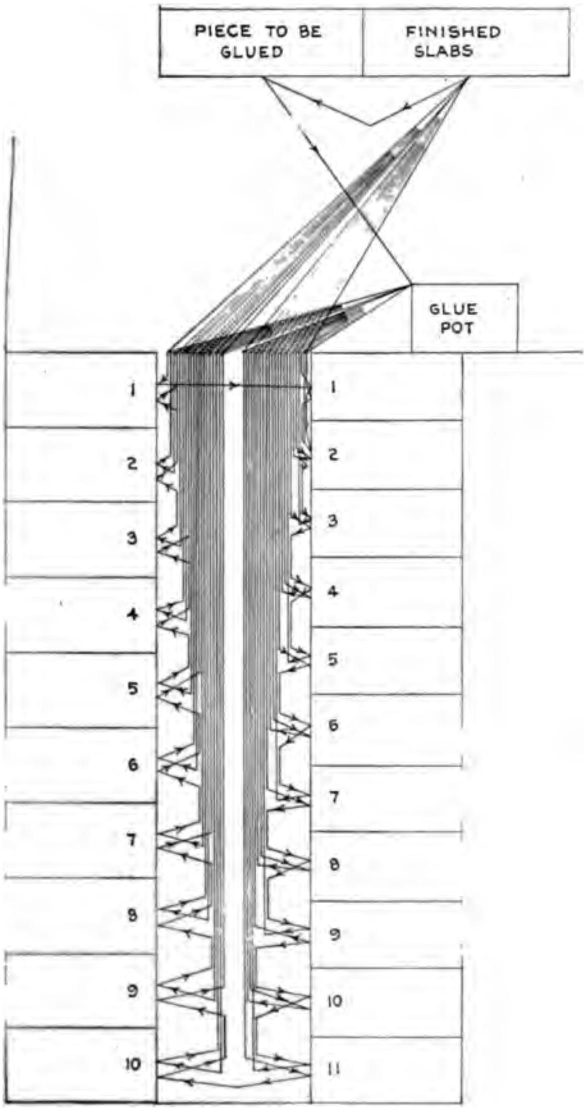


FIGURE 82.—Diagram of Travel of Parts in Glueing Operation

B = Time to pick up two pieces = 0.04 minute
C = Time to glue two pieces = 0.03 minute

D = Time to place in clamp = 0.05 minute
E = Time to pick up one piece = 0.04 minute
F = Time to glue = 0.03 minute
G = Time to place in clamp = 0.05 minute
H = Time to tighten clamp per joint = 0.03 minute
I = Time to drop clamping machine one row per joint = 0.01 minute
J = Time to take out one seat (per joint) = 0.02 minute
z = Allowance for fatigue or rest = 15 per cent
t = Actual time per seat
T = Time allowed per seat

Synthesis

$t = A + B + C + D + E + F + G + H + I + J = 0.34$ minute
$T = (A + B + C + D + E + F + G + H + I + J) \times 1.15 = 0.34 \times 1.15$
$= 0.39$ minute for a seat of three joints
$= 0.13$ minute is time allowed per joint

We have found that seats of different kinds of wood contain a different number of pieces as follows:

Gum, Birch and Oak, 4 pieces of stock—3 joints
Maple, 5 pieces of stock—4 joints
Chestnut, 9 pieces of stock—8 joints

Time allowed per joint = 0.13 minute.
Time allowed for seats of gum birch and oak = $0.13 \times 3 =$ 0.39 minute.
Time allowed for 100 seats = $0.39 \times 100 = 39$ minutes or 0.65 hour
Time allowed maple seats = $0.13 \times 4 = 0.42$ minute
Time allowed for 100 seats = $0.42 \times 100 = 42$ minutes or 0.70 hour
Time allowed chestnut seats = $0.13 \times 8 = 1.04$ minutes
Time allowed for 100 seats = $1.04 \times 100 = 104$ minutes or 1.73 hours

Gluing-up Slabs

Large slabs for table-tops, because of their size and the difficulty to prevent buckling, cannot always be glued-up by a continuous process such as described for seats. They are often glued up in hand clamps. The following bonus rate with Figures 81, 82, 83, and 84 describe this method and illustrate how careful

motion and time studies assist in making such manual operations efficient.

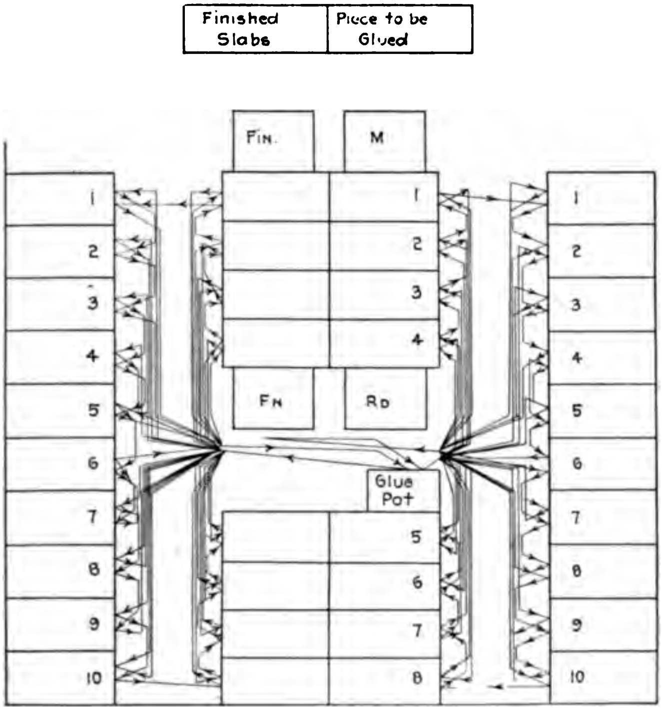


Figure 83.—Another Arrangement for the Travel of Parts in Glueing Operation

Bonus Rate for Matching and Gluing-up Slabs

Rate Symbol

6-G-1 (Clampers)
6-G-2 (Clampers)
6-G-3 (Clampers)
6-G-4 (Clampers)
6-G-M (Matchers)

Time Allowed

6-G-1 = 26.6 minutes = 0.443 hour per 100 slabs
6-G-2 = 39.8 minutes = 0.66 hour per 100 slabs
6-G-3 = 79.6 minutes = 1.327 hours per 100 slabs
6-G-4 = 111.0 minutes = 1.85 hours per 100 slabs

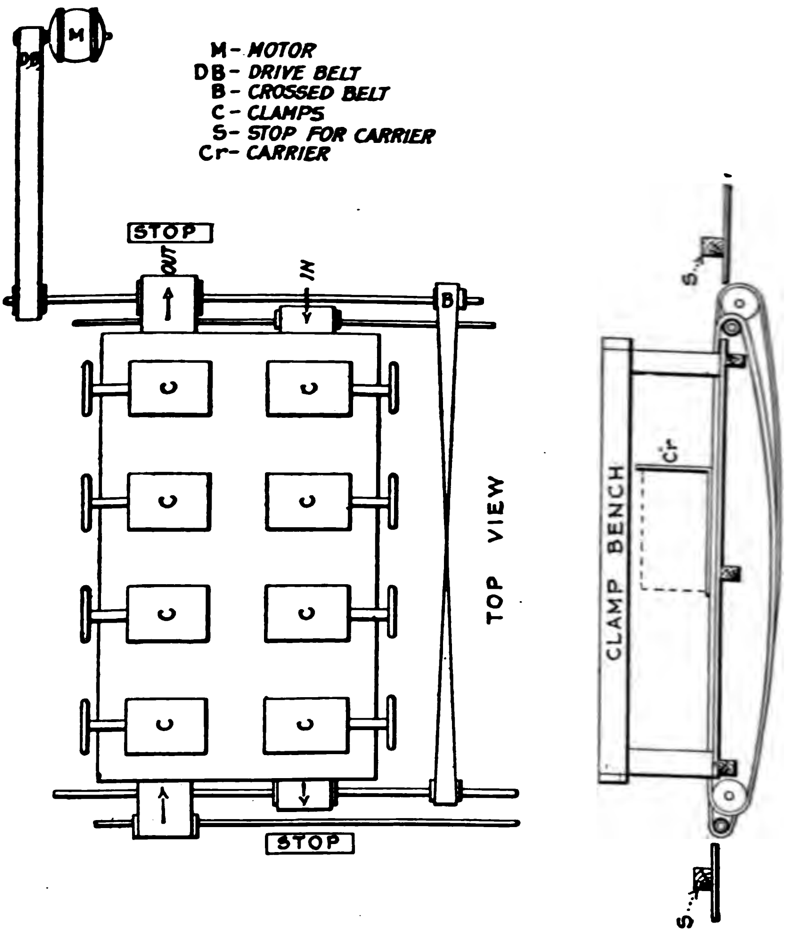


FIGURE 84.—Arrangement of Clamp Bench and Clamps for Glueing

Work Handled Under this Rate

6-G-M = Matching of all lumber to be glued up into slabs
6-G-1 = Gluing-up all slabs 3 in each clamp
6-G-2 = Gluing-up all slabs 2 in each clamp
6-G-3 = Gluing-up all slabs 1 in each clamp
6-G-4 = Gluing-up all slabs 1 in two clamps

Description of Present Conditions and Cost

The operation is now performed as outlined graphically on addenda A and B (Figures 81 and 82) by two matchers and

six clampers. Records show that they have averaged 1300 clamp-fulls per day at a unit cost of $0.0153 per clamp.

Recommendations for Standardization of Conditions and Cost

We recommend that this operation be performed as outlined graphically on addendums A and C (Figures 81 and 83) by two matchers and three clampers. They are to be assisted by the use of the small conveyors suggested on addendum D (Figure 84). We believe that at 95 per cent efficiency they will turn out 2160 clamp-fulls daily at a unit cost of $0.0076. The matchers will match the boards to be clamped and will place them on a small carrier, which will in turn be placed on the In conveyor. At the other end of the conveyor, the clamper will take his boards as he needs them, will apply the glue, and proceed to clamp them as at present, but with this difference, he will only have to travel 826 feet to reach 36 clamps (23 feet per clamp) whereas, at present he travels 965 feet to reach 21 clamps (46 feet per clamp). The finished slabs, which he removes, will be placed on the Out conveyor, and the matchers at the other end will remove same and place on trucks.

All material will be trucked in and out of department by the matchers.

Analysis

A = Time to pick up pieces = 0.07 minute
B = Time to walk to glue pot = 0.04 minute
C = Time to apply glue = 0.02 minute
E = Time to place boards on clamp = 0.09 minute
F = Time to clamp = 0.25 minute
G = Time to loosen two clamps = 0.12 minute
H = Time to remove slabs from two clamps = 0.04 minute
Time for walking to and from 36 clamps (one round) = 3.60 minutes
L = Average time for walking to and from clamp = 3.60/36 = 0.10 minute (30 inches per 0.01 minute = clamper's walking rate of speed)
M = Time to change empty carriers = 0.50/12 = 0.042 min.

Synthesis

T = Time allowed per 100 slabs
t = Actual time per 100 slabs

6-G-1

As there are 3 slabs to a clamp under this rate

$$\frac{A+B+C+E+F+\frac{G}{2}+\frac{H}{2}+L+M}{3}=\frac{0.692}{3}=0.231 \text{ minute}$$

per slab

$t=0.231\times100=23.1$ minutes per 100 slabs

$z=$Allowance for rest and delays $=15$ per cent

$T=1.z(t)=1.15\ (23.1)=26.6$ minutes $=0.443$ hour per 100 slabs

6-G-2

As there are 2 slabs to a clamp under this rate

$$\frac{A+B+C+E+F+\frac{G}{2}+\frac{H}{2}+L+M}{2}=\frac{0.692}{2}=0.346 \text{ minute}$$

per slab

$t=0.346\times100=34.6$ minutes per 100 slabs

$z=$Allowance for rest and delays $=15$ per cent

$T=1.z(t)=1.15(34.6)=39.8$ minutes $=0.66$ hour per 100 slabs

6-G-3

As there is but one slab to a clamp under this rate

$A+B+C+E+F+\frac{G}{2}+\frac{H}{2}+L+M=0.692$ minute per slab

$t=0.692\times100=69.2$ minutes per 100 slabs

$z=$Allowance for rest and delays $=15$ per cent

$T=1.z(t)=1.15(69.2)=79.6$ minutes $=1.327$ hours per 100 slabs

6-G-4

$A+B+C+E+2F+G+H+L=0.96$ minute per slab

$t=0.96\times100=96$ minutes per 100 slabs

$z=$Allowance for rest and delays $=15$ per cent

$T=1.z(t)=1.15(96)=111$ minutes $=1.85$ hours per 100 slabs

Veneering

Excepting the veneering of flat panels, the veneering department of a furniture factory presents a serious problem for scientific control, as the majority of operations are short, com- d mostly manual rather than machine. The following

two bonus rates, however, illustrate how such work can be standardized and controlled.

Bonus Rate for Veneering Edges

Rate Symbol

Changing Setting—44—VES
Clamping—44—VE

Time Allowed

Changing Setting 44 – VES = 1.00 minute = 0.017 hour per setting

Clamping 44 – $VE = 46r + 27.6s + 115$ minutes $= 0.767r + 0.463s + 1.92$ hours per 100 sides or ends veneered

wherein

r = Number of pieces veneer applied at one setting
s = Number of screws necessary to clamp piece

Work Handled Under This Rate

Veneering edges of tops, shelves, bases, etc., which are of straight or irregular form where the veneer is applied and which are veneered on presses VEP 1-7. VES covers the changes in setting when changing from long work to short work, etc.

Description of Present Condition and Cost

There are two and sometimes three women operatives working on these presses at present. The pieces are taken from a pile, which is 10 to 30 feet away from the presses, and are carried to and placed upon the presses; the form (if any) which has been cut away from them on the band saw, or a straight strip of wood about 1 inch x 2 inches is greased with hard grease to prevent the glue from sticking the veneer to it; the piece of veneer is placed on the edge and form or strip placed upon it, and the screws are then clamped down. When taking out of the press, the screws are loosened, the work is removed and carried to a pile and the forms are knocked off.

Recommendation for Standardization of Conditions and Cost

The department utility man should keep work on a truck constantly supplied to the operatives. This will eliminate a great loss of time which is at present experienced. Under the bonus incentive there will be no tendency to loiter and fewer delays will be the consequence.

More presses should be built so that the larger work, where one piece in a press is necessary, can be constantly handled, instead of letting the operatives do a lot of little jobs while allowing the veneer to dry. Fifteen presses are necessary to accommodate the larger pieces and keep two women constantly employed. On the smaller work an extra woman can be used to keep the presses filled.

Analysis:

A = Time to place pieces on press (per piece) = 0.15 minute
B = Time to walk to and from bench = 0.20 minute
C = Time to apply grease to form or straight strip = 0.10 minute
D = Time to apply glue to strip of veneer = 0.10 minute
E = Time to place strip of veneer on form or straight strip = 0.20 minute
F = Time to place block of wood across top = 0.15 minute
G = Time to clamp (per screw) = 0.16 minute
H = Time to unclamp (per screw) = 0.08 minute
I = Time to place on truck and knock off forms = 0.20 minute
r = Number pieces veneer applied at one setting
s = Number screws necessary to clamp piece
z = Allowance for rest and delays = 15 per cent

Synthesis

T = Time allowed per 100 similar sides or ends veneered
t = Actual time per 100 sides or ends veneered

$$t = 100[A + 2B + r(C + D + E) + F + s(G + H) + I]$$
$$= 100[0.15 + 0.40 + r(0.40) + 0.15 + s(0.24) + 0.20]$$
$$= 40r + 24s + 100 \text{ minutes}$$
$$T = 1.15(40r + 24s + 100) = 46r + 27.6s + 115 \text{ minutes}$$
$$= 0.767r + 0.463s + 1.92 \text{ hours per 100 sides or ends veneered}$$

BONUS RATE FOR SPREADING GLUE AND PRESSING FLAT STOCK

Rate Symbol

30 VP1 (Clamped in large press and placed in retainers)
30 VP2 (Clamped in large press but not placed in retainers)
30 VP3 (Clamped in small press and placed in retainers)
VP4 (Clamped in small press but not placed in retainers)

Time Allowed

30—VP1

$$\frac{3.45npr+40r+57.5s+46v+95.5}{y} \text{ minutes}$$

$$=\frac{0.058npr+0.666r+0.958s+0.766v+1.592}{y} \text{ hours per 100 finished slabs}$$

30—VP2

$$\frac{3.45npr+40r+57.5s+9.2}{y} \text{ minutes}$$

$$=\frac{0.058npr+0.666r+0.958s+0.15}{y} \text{ hours per 100 finished slabs}$$

30—VP3

$$\frac{3.45npr+40r+28.75s+46v+95.5}{y} \text{ minutes}$$

$$=\frac{0.058npr+0.666r+0.479s+0.766v+1.592}{y} \text{ hours per 100 finished slabs}$$

30—VP4

$$\frac{3.45npr+40r+28.75s+9.2}{y} \text{ minutes}$$

$$=\frac{0.058npr+0.666r+0.479s+0.15}{y} \text{ hours per 100 finished slabs}$$

wherein

n = Length of veneer expressed in feet
p = Number pieces possible to run through spreader and place on pile before carrying
r = Number times necessary to carry to press before clamping in press
s = Number screws used in press to clamp work down
v = Number of pairs of screws used to clamp pile in retainers
y = Number of slabs clamped in press at one setting

Work Handled Under This Rate

All flat work such as table tops, shelves, etc., which has the **glue spread with the** machine spreader and which is placed in

Analysis

A = Time to run piece through spreader and place (per lineal foot) = 0.03 minute
B = Time to carry to press = 0.20 minute
C = Time to place in press = 0.15 minute
D = Time to clamp in large press (per screw) = 0.50 min.
E = Time to clamp in small press (per screw) = 0.25 minute
F = Time to clamp in retainer (per pair of screws) = 0.40 minute
G = Time to unscrew and remove from press = 0.40 minute
H = Time to make press ready (place I-beams) = 0.35 minute
I = Time to return from press = 0.08 minute
n = Length in feet of piece run through spreader
p = Number of pieces possible to run through spreader and place on pile before carrying to press
r = Number times necessary to carry pile to press before clamping in press
s = Number of screws used in press to clamp work down
v = Number of pairs of screws used to clamp pile in retainers
y = Number of slabs clamped in press at one setting
z = Allowance for rest and delays = 15 per cent

Synthesis

T = Time allowed per 100 slabs
t = Actual time per 100 slabs

VP–1 (Clamped in large press and placed in retainers)

$$t = \frac{100}{y} [r\,(Anp + B + C) + Ds + Fv + G + H + I]$$

$$= \frac{100}{y} [r\,(0.03np + 0.20 + 0.15) + 0.50s + 0.40v + 0.40 + 0.35 + 0.08]$$

$$= \frac{100}{y} [0.03npr + 0.35r + 0.50s + 0.40v + 0.83]$$

$$= \frac{3npr + 35r + 50s + 40v + 83}{y}$$

$$T = 1.2\,\frac{(3npr + 35r + 50s + 40v + 83)}{y}$$

$$=1.15\frac{(3npr+35r+50s+40v+83)}{y}$$

$$=\frac{3.45npr+40r+57.5s+46v+95.5}{y}\text{ minutes}$$

$$=\frac{0.048npr+0.666r+0.958s+0.766v+1.592}{y}\text{ hours per 100 finished slabs}$$

(Clamped in large press, but *not* placed in retainers)

$$=\frac{100}{y}[r(Anp+B+C)+Ds+I]$$

$$=\frac{100}{y}[r(0.03np+0.20+0.15)+0.50s+0.08]$$

$$=\frac{100}{y}[0.03npr+35r+50s+0.08]$$

$$=\frac{3npr+35r+50s+0.08}{y}$$

$$=1.5\frac{(3npr+35r+50s+0.08)}{y}$$

$$=1.15\frac{(3npr+35r+50s+0.08)}{y}$$

$$=\frac{(3.45npr+40r+57.5s+9.2)}{y}\text{ minutes}$$

$$=\frac{0.058npr+0.666r+0.058s+0.15}{y}\text{ hours per 100 finished slabs}$$

Clamped in small press and placed in retainers)

$$=\frac{100}{y}[r(Anp+B+C)+Es+Fv+G+H+I]$$

$$=\frac{100}{y}[r(0.03np+0.20+0.15)+0.25s+0.40v+40+0.35+0.08]$$

$$=\frac{100}{y}(0.03npr+0.35r+0.25s+40v+0.83)$$

$$= \frac{3npr + 35r + 25s + 40v + 83}{y}$$

$$T = 1.75z \frac{(3npr + 35 + 25s + 40v + 83)}{y}$$

$$= 1.15 \frac{(3npr + 35 + 25s + 40v + 83)}{y}$$

$$= \frac{3.45npr + 40r + 28.75s + 46v + 95.5}{y} \text{ minutes}$$

$$= \frac{0.058npr + 0.666r + 0.479s + 0.766v + 1.592}{y} \text{ hours per 100 finished slabs}$$

VP-4 (Clamped in small press but *not* placed in retainers)

$$t = \frac{100}{y}[r(Anp + B + C) + Es + I]$$

$$= \frac{100}{y}[r(0.03np + 0.20 + 0.15) + 0.25s + 0.08]$$

$$= \frac{100}{y}(0.03npr + 0.35r + 0.25s + 0.08)$$

$$= \frac{3npr + 35r + 25s + 0.08}{y}$$

$$T = 1.z \frac{(3npr + 35r + 25s + 0.08)}{y}$$

$$= 1.15 \frac{(3npr + 35r + 25s + 0.08)}{y}$$

$$= \frac{3.45npr + 40r + 28.75s + 9.2}{y} \text{ minutes}$$

$$= \frac{0.058npr + 0.66r + 0.479s + 0.15}{y} \text{ hours per 100 finished slabs}$$

Operator C will be considered in charge of this work. He will stamp card at start and finish of each job.

Helper's time will be figured from operative's.

Operator C will prepare the veneer, set the press, clean up, etc., on straight labor time.

Bonus rates such as the above may be worked out for all operations in the department with any considerable volume, but there are always a few small operations which can only be standardized in a general way.

The following instruction and the sketch shown in Figure 86 illustrate the method of standardization of such minor operations.

General Conditions Governing the Output of the Veneer Room

General

Standard instructions have been issued covering jointing veneer, operating taping machine, gluing taped joints, ripping

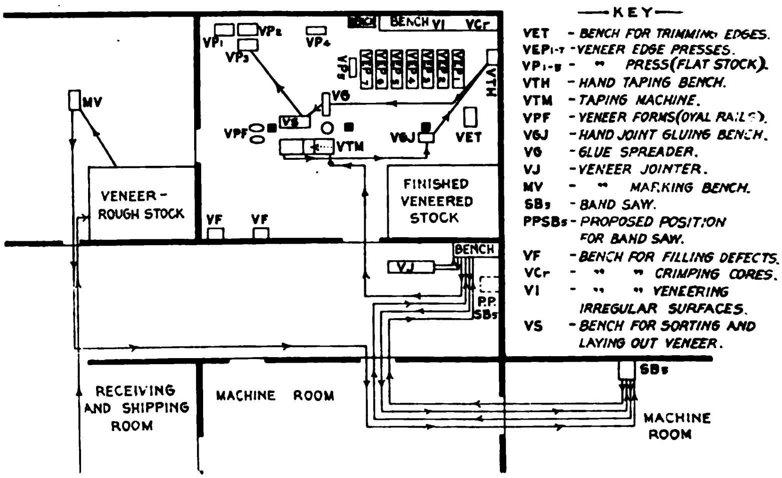


Figure 86.—Illustration of Standardization of Minor Operations

cores, ripping out defects, crimping cores, spreading glue on built-up oval rails and placing same in forms, veneering edges, and spreading glue and pressing flat stock. It was found to be impracticable to make up bonus rates to cover the remainder of the operations performed in the veneer room.

Referring to addendum to this instruction (Figure 86) the routing of the rough stock is found to cover a considerable distance until it has been jointed, due to the distance of the band saw SB-5 from the rest of the veneer room equipment. By moving the band saw to its proposed location by the veneer jointer, an average of 5 minutes on each operation performed on the band saw will be saved.

The operations on the machine shown by this symbolization in the addendum to this instruction are performed as follows:

Duties

One operative performs the operation of cutting veneer to length, ripping out defects, and ripping cores on band saw SB-5; jointing veneer on veneer jointer VJ; and veneering irregular surfaces on bench VI. He should also do the marking and sorting of veneer before cutting off.

Another operative performs the operation of trimming edges on bench VET, besides assisting the first operative with the veneering of irregular surfaces.

Three operatives work together in a gang to perform the operations of spreading glue on glue spreader VG; placing in forms VPF; pressing flat stock in presses VP-1-5; gluing up blocks and gluing on moulding in presses VP-1-5; and piling to dry. When working separately they perform the operations on crimping cores by hand on bench VER; sorting and laying out veneer on bench VS; and trimming edges on bench VET.

One girl operative does the gluing of joints on bench VGJ; hand taping on bench VTH; and machine taping on machine taper VTM with the assistance of a woman helper.

Two women handle the veneering of edges on clamps VEP-1-7. The woman who assists with the machine taping should also help on this job when large work is handled, care being taken by the Planning Department that the two jobs are not scheduled at the same time.

The department utility man should look after the filling of defects on bench VF besides his regular duties. At present one man is kept at this work practically all the time, but he is an exceedingly slow workman.

The foreman should be kept informed by the Planning Department of the work to be performed which is not handled under the bonus rates, so that he can do the necessary scheduling and planning of his work. As far as possible the work should be planned to follow through in large quantities.

Recommendations

One of the big factors limiting the production in the Veneer Department is the lack of running the work through in large enough quantities. For instance, the man who sorts and lays out veneer preparatory to running through spreader and pressing, generally only lays out enough for about three pressfuls. Hearty co-operation between the foreman of this department and the

chief of the Planning Department will result in an increase of about 50 per cent in production from this department.

Finally, the efficiency of the department as a whole is built up by devising a bonus for the foreman, which acts as an incentive for him to maintain a high average efficiency among all the employees in his department. This placing of the foreman on bonus should be accomplished in every department where possible. A standard instruction covering the foreman of a veneer department is given here.

Bonus Rate for Efficiency Bonus for Foreman of Veneer Room

Rate Symbol

AFV

Standard Duties

General supervision of the men and women doing all the veneering operations throughout the plant. There shall never be more than nine operatives employed in this department to handle the capacity of the plant as at present laid out.

It will be his duty to see that each person responsible to him stamps his or her time cards properly, and he shall do everything possible to see that each of his operatives on bonus attain 100 per cent efficiency. He is required to thoroughly understand each operation performed in his department, see that operatives perform their duties properly, and shall instruct all new operatives.

He shall co-operate with the Planning Department in the scheduling and routing of all work through this department which is not covered by bonus rates. As far as possible this work shall be scheduled through in large quantities.

He shall inspect the quality of the work produced by his department, striving to maintain the highest standard of quality at all times.

Bonus

He shall be paid a day rate of $0.35 per hour and a base rate of $0.385 per hour, plus a bonus percentage equivalent to the average bonus percentage made by the operatives in his department. Bonus will be based on curve shown in Figure 116. It is understood that this average must be based upon all persons in his department working upon bonus jobs, whether they are experienced or not.

Planing

The operation of planing is fairly simple, but the efficiency is often lowered through one of two faults. The first is failure to plan similar thicknesses in sequence, thus necessitating excessive setting-up; the second is to properly fix the rates. The variable effect of various combinations of the length and width of stock render rate setting very difficult and the piece rates found in

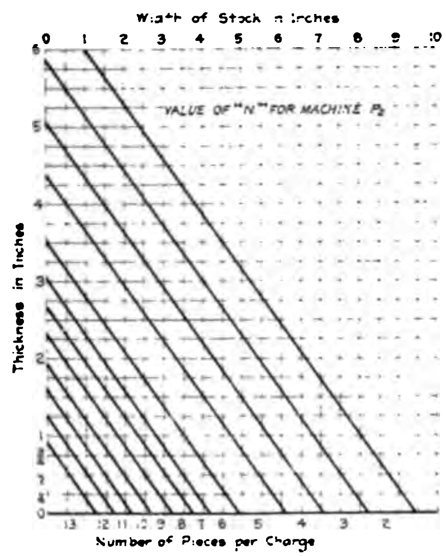


FIGURE 87.—Values of N for Wood Planer

the average woodworking factories are very unscientific and unfair.

The following rate outlines a method of figuring planer capacities which is believed to be not only original, but absolutely fair to the operative.

BONUS RATE FOR PLANING STOCK

Rate Symbol

8-15-P2S Setting-up
8-15-P2 Operating (where L is not limiting factor)
8-15-P2A Operating (where L is limiting factor)

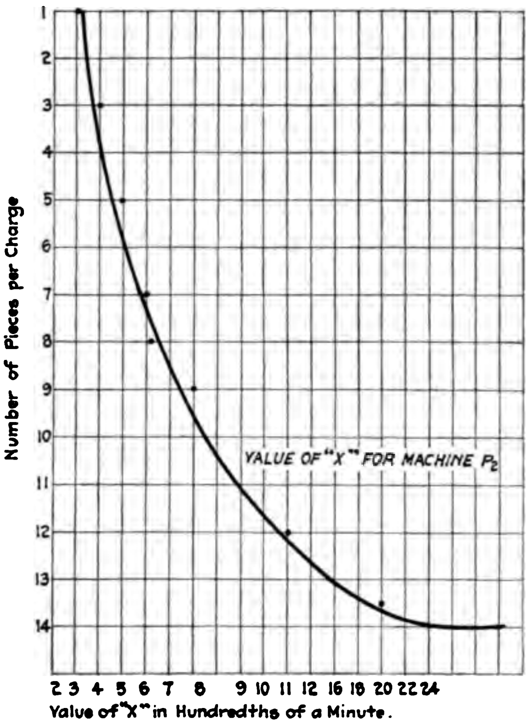


FIGURE 88.—Value of X for Planing Operation

Time Allowed

8-15-P2S Setting-up = 2.50 minutes = 0.042 hour per set-up
Operating-variable according to size of stock
Substitute values of N, X, and L obtained from Charts A B, and C (Figures 87, 88 and 89 respectively) in the following formulæ:

$$8\text{-}15\text{-P2} = \frac{0.192 + 1.92X}{N} \text{ hours per 100 pieces}$$

$$8\text{-}15\text{-P2A} = 0.005\,\frac{N}{L} \text{ hours per 100 pieces}$$

Work Handled Under This Rate

All stock planed on the planer 8-15-P2

Description of Present Conditions

This operation at present consists of the operator bringing a

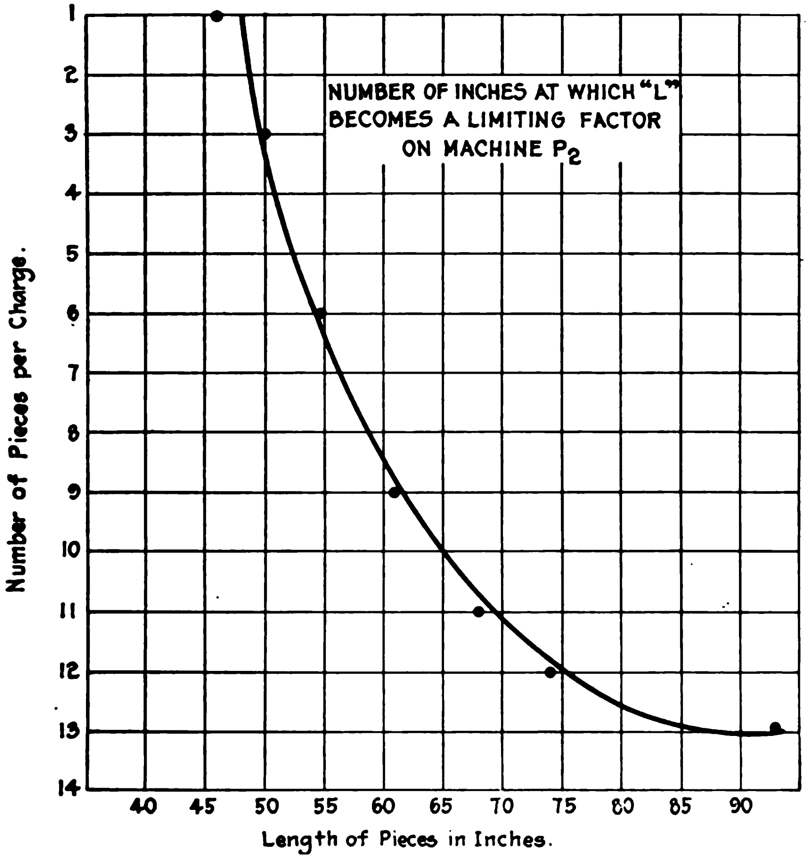


FIGURE 89.—Relationship of Length of Pieces and Number of Pieces Per Charge in Planing

truckload of parts to the machine, setting the machine, and taking piece or pieces from truck and forcing them into the machine.

Analysis

A = Time to pick up pieces = 0.06 minute
X = Time to sort pieces (See Figure 88)
C = Time to feed into machine = 0.04 minute
L = Length of pieces in inches (See Figure 89)
N = Number of pieces per charge (See Figure 87)
S = Speed of machine (under load) = 336″ per minute
z = Allowance for rest and delays = 15 per cent

Values of X, N and L are determined from the curves in addenda to this instruction.

$$\frac{100}{N} = \text{Number of charges per minute}$$

Synthesis

T = Time allowed per 100 parts
t = Actual time required per 100 parts

$$t = \frac{100}{N}(0.10 + X) = \frac{10 + 100X}{N}$$

$$T = 1.15\left(\frac{10 + 100X}{N}\right) = \frac{11 + 115X}{N} \text{ minutes}$$

$$= \frac{0.192 + 1.92X}{N} \text{ hours per 100 parts}$$

Where L becomes a limiting factor,

$$\frac{S \times 60}{L}N = \frac{336 \times 60}{L}N = 20160\frac{N}{L} = \text{number pieces per hour}$$

or

$$\frac{L}{201.60N} = \text{time per 100 pieces} = \frac{1}{201.6} \times \frac{L}{N} = T$$

$$T = 0.005\frac{L}{N} = \text{hour time per 100 pieces}$$

Bonus

Day rate
Operator........................ \$0.30 per hour
Helper........................ 0.225 per hour

Base rate
Operator........................ 0.33 per hour
Helper........................ 0.25 per hour

Pay bonus based on curve shown in Figure 116.

Planning Department will plan time of trucker who will bring truckload of stock to machine, when operator is ready to commence work.

Piece counter will report production from direct count of pieces planed.

Helper's time will be figured from operator's cards.

A different method of rate-setting is outlined below, determined in a somewhat similar manner, but charted.

Bonus Rate for Planing

Rate Symbols

Setting—13-PS

Operating—13P

Time Allowed

Setting = 2.50 minutes = 0.042 hour per set-up

Operating = Variable

Work Handled Under This Rate

All stock which is planed. It is of various lengths, widths and thicknesses. The work is handled by two planers, double surfaces which plane both sides of a piece of stock at the same time.

Data

Maker of Machine—Holt, Shattuck & Co., Boston, Mass.

Revolutions per minute of shaft = 3300

Four knives on each shaft

Number of cuts per minute, per inch = 45

Description of Present Condition

It takes two men to run each machine. The operator feeds the machine and the helper inspects the stock as it comes out of the machines. He has two trucks; on one he piles the good stock and on the other he piles poorly planed stock and stock in which the imperfections are so bad it cannot be used. The supplying of work is very poor. Machines should not be run when knives are dull.

Recommendations for Standardization of Condition

One machine should be used always for the largest and coarsest work and the best machine should be kept for the lighter and better class of work.

Under standardized conditions supplying will be taken care of.

When running small sizes of stock the supply table should be used, because the operator loads table full and then he will have a chance to rest from bending over while he is running the table full. Otherwise he is continually bending over to pick up a few pieces at a time.

The speed of the machine is correct. Table 6 shows the number of lineal feet that should be done per minute of the various lengths and widths of stock.

Analysis

Table 6 shows the number of lineal feet per minute of stock of various widths and lengths.

These results were obtained by a careful study on operating the machine. We took the width of the bed of the planer (which is 24 inches wide) as 100 per cent efficiency and we studied to find out what per cent of 100 per cent the operator could actually keep full—this always varies with the width of the stock.

All stock up to 1 inch in width is considered as 1 inch wide and stock over 1 inch up to and including 2 inches is figured as 2 inches wide, etc.

The per cent operator can keep filled will gradually increase from 1 inch wide to 5 inch wide. At 6 inches wide it will decrease a little and then it will gradually increase until he fills the machine to 100 per cent capacity. There will always be stock that will have to be planed the second time and we have made an allowance for the same.

Bonus will be always figured by 100 lineal feet.

Speed of feed = 222 inches per minute

Width of bed = 24 inches

A = Number of lineal feet per minute
t = Actual time per 100 lineal feet
T = Time allowed per 100 lineal feet
z = Allowance for rest or fatigue = 10 per cent
x = Allowance for stock that has to be planed the second time

Synthesis

$$t = \frac{1.00}{A} \times 100 \text{ minutes}$$

$$T = t \times 100z$$
$$= t \times 1.20$$
$$= 1.20t$$

Example: Stock 30 inches long, 1 inch wide, 82 lineal feet per minute.

$$t = \frac{1.00}{82} \times 100 = 1.22 \text{ minutes per 100 lineal feet}$$

$$T = 1.22 \times 1.20$$
$$= 1.46 \text{ minutes, or } 0.0243 \text{ hour per 100 lineal feet}$$

Bonus Rate

	Operator	Helper
Day rate	= \$0.33	\$0.30
Base rate	= \$0.36	\$0.33

Work will be taken to and from the machine by the department trucker. Operator will stamp Start and Stop of each job on his card.

Table 6—Planing Speeds for Various Lengths and Widths of Lumber (Symbol P)

Length of Piece	Speed in Lineal Feet per Minute — Width of Piece in Inches											
	1	2	3	4	5	6	7	8	9	10	11	12
6	82	66.5	54	55	55	37	39	37	37	37	39	37
8	82	66.5	54	55	55	37	39	37	37	37	39	37
10	82	66.5	54	55	55	37	39	37	37	37	39	37
12	82	66.5	54	55	55	37	39	37	37	37	39	37
14	82	66.5	54	55	55	37	39	37	37	37	39	37
16	82	66.5	54	55	55	37	39	37	37	37	39	37
18	82	66.5	54	55	55	37	39	37	37	37	39	37
20	82	66.5	54	55	55	37	39	37	37	37	39	37
22	82	66.5	54	55	55	37	39	37	37	37	39	37
24	82	66.5	54	55	55	37	39	37	37	37	39	37
26	82	66.5	54	55	55	37	39	37	37	37	39	37
28	82	66.5	54	55	55	37	39	37	37	37	39	37
30	82	66.5	54	55	55	37	39	37	37	37	39	37
32	82	66.5	54	55	55	37	39	37	37	37	39	37
34	82	66.5	54	55	55	37	39	37	37	37	39	37
36	82	66.5	54	55	55	37	39	37	37	37	39	37
38	82	66.5	54	55	55	37	39	37	37	37	39	37
40	82	66.5	54	55	55	37	39	37	37	37	39	37
42	82	66.5	54	55	55	37	39	37	37	37	39	37
44	82	66.5	54	55	55	37	39	37	37	37	39	37
46	82	66.5	54	55	55	37	39	37	37	37	39	37
48	82	66.5	54	55	55	37	39	37	37	37	39	37
50	82	66.5	54	55	55	37	39	37	37	37	39	37
52	82	66.5	54	55	55	37	39	37	37	37	39	37
54	82	66.5	54	55	55	37	39	37	37	37	39	37
Capacity of Machine Used....	0.185	0.30	0.37	0.50	0.60	0.50	0.63	0.67	0.75	0.83	0.92	100

10 per cent allowance for poor stock. 10 per cent allowance for rest and fatigue.

Sticking

The principal requirements in efficiently operating stickers are the proper grinding and setting of the knives and so routing the stock for the operation that excessive setting up is avoided. Suppose the following cross-sections of stock occur on orders for a certain day,

[illegible] orders [illegible] inch by [illegible] inch
[illegible] [illegible] inch by [illegible] inch
[illegible] [illegible] inch by [illegible] inch
[illegible] [illegible] inch by [illegible] inch

The various orders for the same cross-sections should not only be run together, but also the different sizes in the sequence in which the orders are listed above, as this necessitates the least

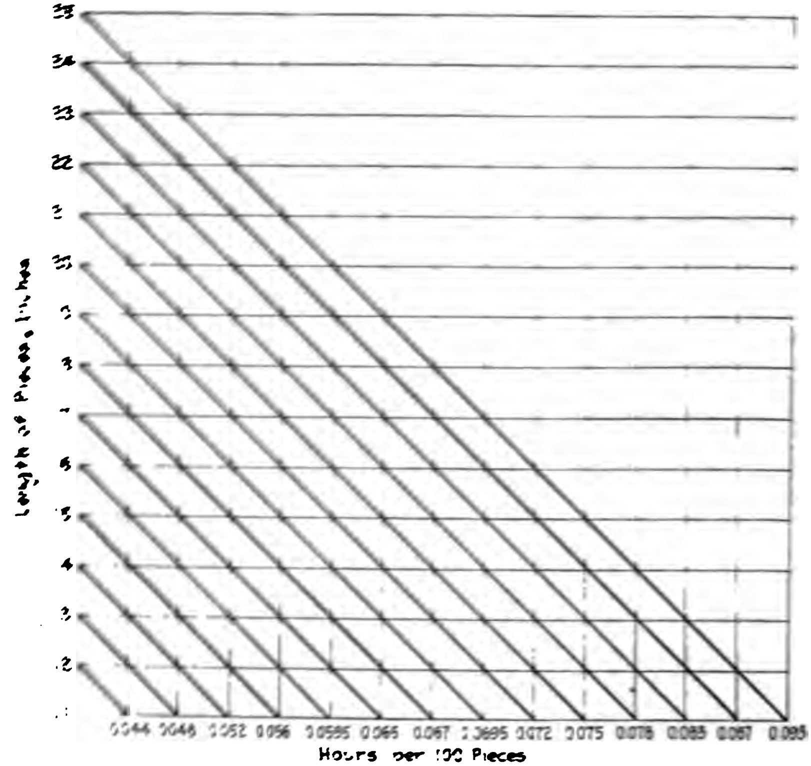


Figure 90. Time Allowance Chart for Different Length Parts on a Sticker

amount of knife adjustment. A good rule is—group the sizes and run from the smallest to largest or vice-versa, running those sizes next to each other which have one common dimension.

Figure 90 shows a time allowed chart for running various length parts on a sticker at 42 feet per minute feed.

Turning, Chucking, Boring, Mortising, Tenoning, etc.

These operations are simple to control, but considerable economy may be realized by supplying and taking away

the product in trucks of proper design, in eliminating hand-feeds, thus making the operators feed the stock into the machines automatically at regular intervals, and by the use of multiple spindle machines wherever possible. It is ridiculously wasteful to bore 12 screw holes in several hundred seats day after day on a single-bit boring machine when a multiple-bit machine is available, but the author has seen this very thing happen, and his remonstrance met with the excuse that "it took too much time to set-up the multiple."

On these particular operations the setting-up of the machines is a vital factor. Often mortisers and tenons are under setting-up more hours of the day than they are operating. This can be

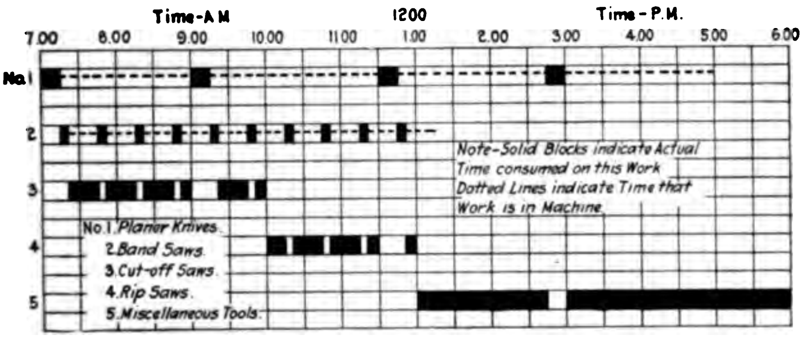


FIGURE 91.—Chart Showing Saw Filer's Duties

somewhat eliminated by standardization of fitting sizes and planning the proper sequence of similar sized fitting operations, but by far the greatest economy can be effected by placing machine setting under special individuals, thus eliminating the setting of machines by the operatives themselves. For instance, a group of six fitting machines can be far more effectually operated by five operatives and one machine setter than by six operatives each doing his own setting-up.

An example of how the duties of a machine setter may be standardized is shown in Figure 91, a graphic chart of a saw filer's duties, and in the following standard instruction. A machine setter proper, of course, moves from machine to machine as the orders occur, but a more or less standard routine can be worked out as a basis of control.

Bonus Rate for Duties of Saw Filer in Machine Room

Rate Symbol

ASF

Standard Duties

A He shall apportion his time as shown in addendum A to this instruction, having a sufficient supply of sharp tools on hand at all times so that operators of machines will experience no delays from this source.

B He shall grind all cross-cut circular saws as shown in addendum B to this instruction, making angles *a* and *c* larger as the wood which is to be cut is harder than birch, and making the angles *a* and *c* smaller as the wood to be cut is softer than birch. At present the angle *b* is zero, giving no clearance to the blades. By making angle *b* 15 degrees a smooth free cut is produced.

C He shall be under the direction of the foreman of the machine department.

D He shall report any variations from his regular schedule directly to the Planning Department.

E When the machine setter is working with him on the sharpening of miscellaneous tools, he shall direct the efforts of the machine setter to the end that all tools shall be kept in a state of constant repair and sharpening.

Bonus

He shall be paid a day and base rate of $0.35 per hour plus a bonus percentage equivalent to the average bonus percentage made by the operatives to whom he supplies tools. Bonus will be based on curve shown in Figure 116.

Bending

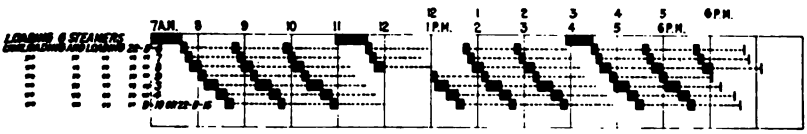
The operation of bending is usually executed by a very low grade of labor due to the fact that poor ventilating conditions render the department so hot in warm weather that few high-grade men will work there. The equipment is very varied and often very crude. The first operation is to soften the wood. The best equipment for this consists of iron retorts in which the wooden parts are steamed under pressure, but in a few plants it is still the practice to soak the wood in vats of hot water.

After steaming, the actual bending takes place in one of two ways, in straps or in steam-heated hydraulic (sometimes worm) presses. When bent in straps the wood is placed on flexible

metal bands, bent into the required shape, either by hand or by machine, and then held in shape by means of metal grips or clamps until it cools. These devices are often quite cleverly designed. All material bent in straps is usually placed in hot rooms to dry in the clamps. Rates for this work may be simply set, as the operations are usually simple manual ones.

In most plants the moving of the strapped material in and out of the kilns or hot-rooms is very ineffectual, involving considerable re-handling. In a few, however, the material is placed on trucks running on tracks through the center of the department and transported directly through continuous kilns in a very efficient manner.

The control of bending stock in presses, however, requires considerable study and effort. In the first place, the determina-



NOTE: Black represents Time worked by the Operator in Unloading and Loading each Press as Indicated and also Time required to Stack the Parts taken from the Press on a Truck at the Side of the Room.

Dotted Line represents Time required to Dry and Form the Parts in the Press Properly, longer Time than is Shown by the Dotted Line will do no harm but is Unnecessary.

NOTE: When Operation is continued through the Noon Hour Read Upper Scale for P.M. Time.
When Operation is not continued through the Noon Hour Read Low - Scale for P.M. Time.

FIGURE 92.—Chart of Operations on a Bending Press

tion of the proper time to leave the stock in the presses must be studied. This may be determined experimentally by gradually reducing the time in the presses until the parts begin to fail to retain their shape.

The average operative of bending presses is incapable of planning his work. They will first get their presses all full of stock and then all empty. To correct this, cycles of operation must be established as outlined in the following rate, with a graphic control such as shown in Figure 92. The production of hydraulic presses may be increased by placing strap forms beneath the lumber in the presses, which may be locked as the presses close and the strapped parts dried in a hot room. This eliminates the drying time in the presses.

Bonus Rate on Bending Presses

Specification

This rate covers the operation of bending presses 6, 7, 8, 9, 3, 4, and 10 or 15.

[illegible]

22-B6
22-B7
22-B9 $\frac{[illegible]}{[illegible]}$ = Hours per 100 backs or centers

$\frac{[illegible]}{[illegible]}$ = Hours per 100 backs (short bending)

22-B8

$\frac{[illegible]}{[illegible]}$ = Hours per 100 rails (long bending)

22-B3
22-B4 $\frac{[illegible]}{[illegible]}$ Hours per 100 backs, centers, or rails

22-B10 $\frac{[illegible]}{[illegible]}$ Hours per 100 spindles

22-B15 Same as 22-B10 when run in conjunction with presses. When run separately by another operative, see standard instruction 205.

Description of Operation

This work is to be done by one operator in accordance to the schedule laid out in standard instructions 167 (Part II) and shown graphically on the chart attached thereto. (Figure 92.) It is seen from this chart that eight heats can be obtained from presses B6, B7, B8, and B9, and seven heats from presses B3, B4, and B10. It is assumed in these instructions that the planning of work from the Planning Department will allow B10 and B15 to be operated by the same operative alternately, because both of these machines at present stand idle a good part of the time. This will allow all the bending presses on backs, banisters, centers, rails, spindles and turned legs to be operated by one operator as per schedule in Part I.

The production in number of pieces per day at 100 per cent efficiency when operated according to schedule is given below:

B6, B7, B9 $\frac{1728}{W}$ = Number of pieces per day at 100 per cent

B8 $\frac{1152}{W} + \frac{1152}{W}$ = Number of pieces per day at 100 per cent

B3, B4 $\frac{1344}{W}$ = Number of pieces per day at 100 per cent

B10 $\frac{1176}{W}$ = Number of pieces per day at 100 per cent

B15 (Same as B10 when operated under this rate; for other cases, see Standard Instructions, 205)

In all cases, W = width of the piece in inches, and in B8 W' = width of long radius part and W = width of short radius part (commonly called in this plant "straight bend" and "regular bend").

The above rules are the simplest forms of the following formulas:

B1 $\frac{12W}{y}\left(\frac{10+T}{T+t}\right)=P$

B2 $\frac{10W}{y}\left(\frac{10+T}{T+t}\right)=P$

B3 $\frac{4W'}{y}\left(\frac{10+T}{T+t}\right)=P$

Be (when bending forms are used)

$$\frac{4W'}{W}\frac{W}{y}\left(\frac{10+T}{T+t}\right)=P$$

B4 Same as B3 (only long radius press)

B5 $\frac{6W'}{y}\left(\frac{10+T}{T+t}\right)=\mathrm{P}$

B6 $\frac{3W'}{y}\left(\frac{10+T}{T+t}\right)=P$

B7 Same as B3
B8 Same as B3

B8 $2\left(\frac{W'}{24}\frac{W}{y}\right)+\frac{W'}{y'}\left(\frac{10+T}{T+t}\right)=P$

B8 $\frac{2W'}{y'}\left(\frac{10+T}{T+t}\right)$ = number of long radius pieces

B8 $\dfrac{2W'}{24}\dfrac{W}{y}\left(\dfrac{10+T}{T+t}\right)$ = number of short radius pieces

B10 $\dfrac{2W'}{y}\left(\dfrac{10+T}{T+t}\right)=P$

W' = width of platen in inches
W = width of bending form
y = width of piece to be bent in inches
T = time required to dry pieces in press
t = time required to unload and load press
P = production, number of pieces per day

T will vary with the thickness of stock bent, but in all the rules given in this instruction, the constants have been based on the time required to properly form a $\frac{7}{8}$ inch oak back.

Data

Width of platens are as follows:
B1, 2, 5—31 inches effective with 30 inch
Forms—15 inches wide each
B3, 4—48 inches
Forms—24 inches
B6, 7, 9—6 foot
B8—6 foot
B10—6 foot

Bonus

The operator doing work should receive a straight hourly pay of 30 cents and his efficiency should be based on the total number of pieces bent per day. For example, if 100 per cent output for any day figured 1000 pieces, and he produced only 800 pieces, he should receive pay for the whole day based on 80 per cent efficiency. In making the calculation both broken and unbroken pieces should be counted, and all pieces regularly bent in bending forms should be continued to be bent in this manner. It is to be noted, however, that the 100 per cent production of each press will vary from day to day according to the width of the pieces being bent.

Sanding

Sanding is an operation occurring on practically every piece material handled in most woodworking factories. Its stand-

ardization, control and rate-setting require the employment of basic standardization and basic time-studies. The three rates below illustrate the possibilities of such studies. The almost endless variety handled on this operation render the effectuality very low in most sanding departments lacking properly set standards and rates.

Surface Sanding on Continuous Bed-Sander

This type of machine is illustrated in Figure 93. When two machines like this are found in a plant they should be set at

Figure 93.—Continuous Bed Sanding Machine

right angles to each other allowing one operative to receive the stock from one machine and pass into the other such stock as must be sanded on two sides. In this manner three operatives can obtain the same amount of production that four can on two isolated machines.

The machine consists of an endless bed of the platen conveyor type which carries wooden furniture parts under a series of oscillating sanding rolls, delivering them to an operative in the rear of the machine.

The study is two-fold, the production being limited in the case of long stock by the speed of the machine, and in the case of

small stock by the handling time required to sort them before feeding into the machine.

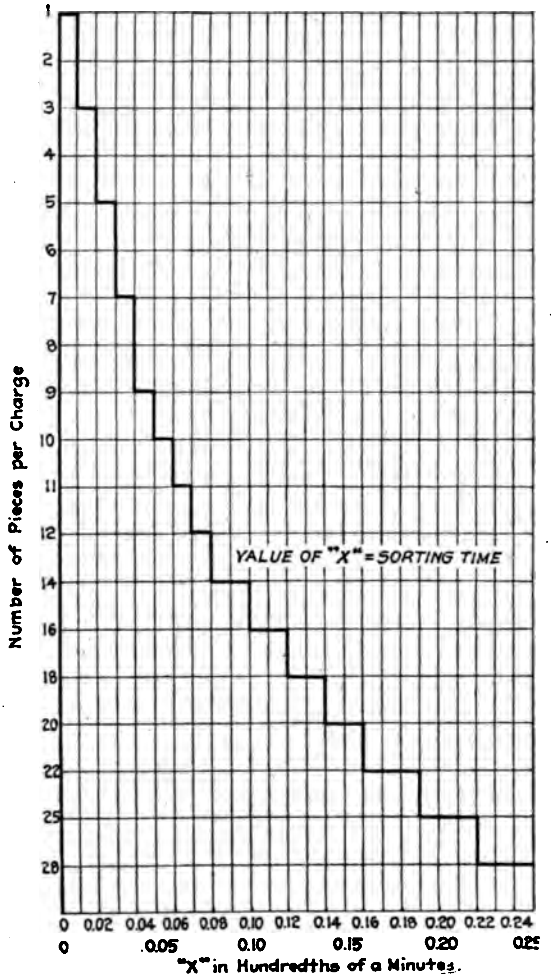


FIGURE 94.—Value of X in Formula for Handling Time Sanding Operations

Analysis

A = Time to pick up pieces = 0.06 minute

B = Time to sort pieces = x minutes. (The value of x for various numbers of pieces was determined by a separate time study and graphically plotted as shown in Figure 94)

C = Time to force into machine = 0.04 minute
L = Length of pieces in inches
N = Number of parts per charge

(The value of N was determined experimentally and graphically plotted as shown in Figure 95. Not only was the size of the charge influenced by the width of the pieces, but thickness also had to be considered to maintain the proper quality of the work.)

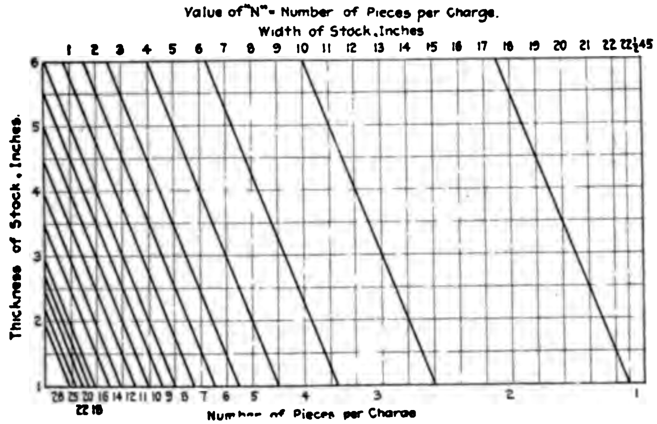


FIGURE 95.—Value of N in Formula in Handling Time in Sanding Operations

S = Speed of machine = 138 inches per minute
z = Allowance for rest and delays = 15 per cent
Handling time per charge = $A + B + C = 0.10 + x$

$\frac{100}{N}$ = Number charges per 100 parts

T = Time allowed per 100 parts
t = Actual time per 100 parts

Synthesis

Case I, where length is not a limiting factor.

In this case the rate is limited by the speed the operative can feed the parts into the machine, therefore,

t = Number of charges per 100 parts times the handling time per charge

$$= \frac{100}{N}(0.10 + x)$$

$$= \frac{10 + 100x}{N} \text{ minutes}$$

Allowing for 10 per cent to be returned for resanding we have

$$t = 1.10 \frac{10 + 100x}{N} = \frac{11 + 110x}{N}$$

$$T = 1.z \frac{11 + 110x}{N} = 1.15 \frac{11 + 110x}{N}$$

$$= \frac{12.65 + 126.5x}{N} \text{ minutes}$$

$$= \frac{0.211 + 2.11x}{N} \text{ hours per 100 pieces}$$

Case II, where length is a limiting factor

$$\frac{\text{Speed of machine}}{\text{Length of pieces}} \times \text{the number of pieces per charge} =$$

$$\text{number pieces per hour} = \frac{SN}{L}$$

$$t = \frac{100}{\frac{SN}{L}} = \frac{100L}{SN} \text{ minutes}$$

Allowing 10 per cent to be resanded.

$$t = 1.10 \frac{100L}{138N} = \frac{1.1L}{1.38N} \text{ minutes}$$

$$T = 1.z \frac{1.1L}{1.38N} = 1.15 \frac{1.1L}{1.38N}$$

$$= \frac{1.265L}{1.38N} \text{ minutes}$$

$$= \frac{1.265L}{82.8N} \text{ hour per 100 pieces}$$

To determine whether the allowance given in Case I or II should be applied reference is made to the graphic chart shown in Figure 96, whereby, given the number of pieces per charge

(found by reference to Figure 95) the length in inches will be found, which if equivalent to or greater than the length of the stock, will indicate that length is the limiting factor and that Case II must be applied.

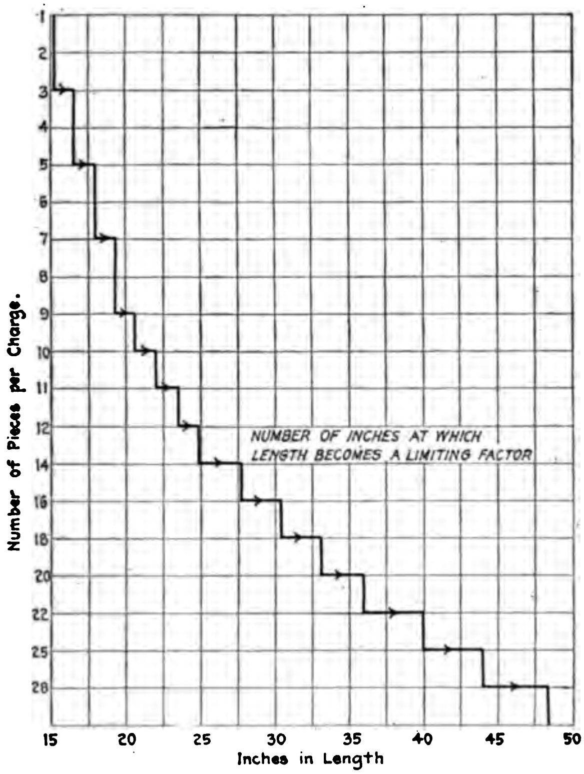


FIGURE 96.—Relationship Between Length of Pieces and Number of Pieces in Bed Sanding Operations

With such a rate as above, a clerk need only know the length, width, and thickness of a piece of stock to determine very easily the time in hours required to run one hundred pieces of such stock.

Bonus Rate for Polish Sanding of Edges

Rate Symbol

59—SdPS—Setting-up
59—SdPC—Changing Sanding Belts
59—SdPE-1—Sanding Edges (parts under 27 inches in length)

[illegible] inches in [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] minutes per 100 parts

[illegible] hours per 100 parts

[illegible]

[illegible] minutes per 100 parts

[illegible] hours per 100 parts

Where

[illegible] = Number of sides of charge necessary to sand
[illegible] = Number of parts per charge
[illegible] = Length in inches of surface sanded
[illegible] = Width in feet of surface sanded
[illegible] = Minutes necessary to turn charge (under [illegible] inches in length) = [illegible] minute
[illegible] = Minutes necessary to turn charge (over [illegible] inches in length) = [illegible] minute

Work Handled Under This Rate

All parts the edges of which are sanded upon the polish sanding machine SdP.

Description of Present Conditions and Cost

The present polish sanding of edges operation consists of the workman taking a charge from the truck, walking to his machine, and placing the charge in a fixture on the movable carriage, arranging the parts when necessary. The parts are then wedged in the fixture and sanded by moving the carriage backward and forward, by the operator's right hand, at the same time applying the moving sand-paper belt, by means of a lever under the op- [illegible] hand, at successive positions from the left to the

right ends of the charge. After sanding the edge, the wedge is removed, and in some instances the parts are turned over and wedged again for the purpose of sanding the other side. Upon completion of sanding, and the final removal of the wedge, the charge is carried to the truck and deposited.

The operator supplies his own stock and provides his own sanding belt by frequent trips to the stockroom and after sanding, trucks the finished parts to one side of the room. A great amount of time is wasted at present in the performance of this sanding operation, both in handling and actual sanding time because of lack of incentive.

Recommendation for Standardization of Conditions and Cost

The time consumed at present in needless walking between trucks and machine will be greatly reduced by more convenient setting of the trucks. Also, the installation of bonus will be an incentive to the operator to decrease handling time by taking more pieces at one time.

The actual sanding time will be reduced, as bonus will neutralize the present tendency to continue the sanding of a charge beyond the time necessary to attain the desired quality of finished surface.

Time now consumed by the operator in trucking and getting sanding belts will be devoted to production, as these duties will be taken care of by the department utility man.

The time allowance for changing sanding belts will be taken care of in the following manner:

The department utility man will provide each morning a supply of sanding belts of various numbers for each machine. As the new belts are required by the operator he will take them from this supply, leaving the used belt in place of the new one.

As each job is completed, the Piece Counter will note, on a piece counter's report, the necessary information in the first seven columns, and under the heading Pieces he will note the number of sanding belts used on each job. He will also make a notation on the face of the form to the effect that it covers a report on sanding belts used. This report is in addition to the regular report on the pieces produced.

The last job worked on will be entered immediately the following morning, and the report placed in a time card box, for the Planning Department, which will complete the allowance to be made the operator for changing belts, and enter this time on operator's card.

Analysis

A = Place charge on machine (parts under 27 inches long) = 0.25 minute
B = Place charge on machine (parts over 27 inches long) = 0.35 minute
C = Wedge parts in fixture = 0.05 minute
D = Time in minutes to sand one surface = x
E = Turn charge (parts under 27 inches long) = 0.20 minute
F = Turn charge (parts over 27 inches long) = 0.25 minute
G = Remove wedge = 0.03 minute
H = Place parts on truck = 0.15 minute
s = Number of sides of charge necessary to sand
W = Width of surface sanded, feet
L = Length of surface sanded, inches

$\frac{L}{2.5}$ = Number of oscillations (cycles) of carriage
$0.08W$ = Time for 1 cycle, minutes per foot of width

$x = \frac{L}{2.5}(0.08W)$ (see D above)
z = Allowance for rest and delays = 15 per cent
N = Number of parts per charge

Synthesis

T = Time allowed per 100 parts
t = Actual time per 100 parts

59—SdPE—1

$$t = \frac{100}{N}(A + sC + sD + E + sG + H)$$
$$= \frac{100}{N}\left(0.25 + 0.05s + s\left[\frac{L}{2.5}(0.08W)\right] + E + 0.03s + 0.15\right)$$
$$= \frac{100}{N}\left(0.25 + 0.15 + s\left[0.05 + \frac{L}{2.5}(0.08W) + 0.03\right] + E\right)$$
$$= \frac{100}{N}\left(0.40 + s\left[0.08 + \frac{L}{3}(0.08W)\right] + E\right)$$
$$= \frac{100}{N}\left(0.40 + 0.08s\left[1 + \frac{LW}{2.5}\right] + E\right)$$

$$=\frac{0.40+8s(1+0.4LW)+100E}{N}$$

$$T=1.2\frac{(40+8s)[1+0.4LW]+100E)}{N}$$

$$=1.15\frac{(40+8s[1+0.4LW]+100E)}{N}$$

$$=\frac{46+9.2s[1+0.4LW]+115E}{N}\text{ minutes}$$

$$=\frac{0.766+0.153s[1+0.4LW]+1.92E}{N}\text{ hours per 100 parts}$$

If but one edge is sanded, E has value of zero, and $s=$ unity

59—SdPE—2

$$t=\frac{100}{N}(B+sC+sD+F+sG+H)$$

$$=\frac{100}{N}\left((0.35+0.05s+s\left[\frac{L}{2.5}(0.08W)\right]+F+0.03s+0.15\right)$$

$$=\frac{100}{N}\left(0.50+s\left(0.08+\frac{L}{2.5}\right)0.08W+F\right)$$

$$=\frac{100}{N}\left(0.50+0.08s\left(1+\frac{LW}{2.5}\right)+F\right)$$

$$=\frac{50+8s+0.4LW+100F}{N}$$

$$T=1.2\frac{(50+8s(1+0.4LW)+100F)}{N}$$

$$=1.15\frac{(50+8s(1+0.4LW)+100F)}{N}$$

$$=\frac{57.5+9.2s(1+0.4LW)+115F}{N}\text{ minutes}$$

$$=\frac{0.958+0.153s(1+0.4LW)+1.92F}{N}\text{ hours}$$

If but one edge is sanded, F has value of zero, and s = unity
Day Rate = \$0.275 per hour
Base Rate = \$0.30 per hour
Pay bonus based on curve shown in Figure 116

Production will be based on direct count made by the piece counter, who will report count to Planning Department, which will enter same on operator's card.

Operator will stamp card at start and finish of each job.

Stock will be delivered and product taken away by department trucker.

Time allowance for changing belts will be based on piece counter's report of sanding belt changed.

Bonus Rate for Sanding on Oscillating Drums

Rate Symbols

Setting up—34D02S
Operating—34D02

Time Allowed

See Table 7

Work Handled Under This Rate

Stock of various shapes, lengths, widths, and thicknesses are smoothed on these machines.

Description of Present Condition

The trucks are pushed to the operator most of the time and he is supplied with an empty truck on which to pile finished pieces.

Any man that the other departments do not need is sent to this department to operate these machines and the result is that the production is low and the operatives slow.

Recommendations for Standardization of Conditions

The productive work is done correctly at present but the men should be taught by the foreman the proper method of performing the work.

Analysis

T = Time allowed
P = Time required to pick up one piece = 0.03 minute
S = Time to smooth piece
D = Time to lay piece on truck = 0.02 minute
z = Fatigue allowance = 15 per cent
t = Actual time allowed

Synthesis

$T = (P+S+D) = 100$

T (per 100 pieces) $= (P+S+D)100 \times 1.15$

Example: One piece of stock under 1½ inches in thickness smoothed on two sides. One side 20 inches to be smoothed and 10 inches on the other side.

$(0\text{-}03+0.07+0.04+0.02)\times 1.15\times 100 = 18.40$ minutes time per 100 pieces, or 0.31 hour per 100 pieces.

TABLE 7—TIME REQUIRED TO SMOOTH BY SANDING VARIOUS LENGTHS OF LUMBER (SYMBOL SdDO)

(All Values are in Minutes)

Length of Surface, Inches	Under 1½ Inches in Thickness	Over 1½ Inches in Thickness	Length of Surface, Inches	Under 1½ Inches in Thickness	Over 1½ Inches in Thickness
1	0.02	0.02	20	0.07	0.08
2	0.02	0.02	22	0.07	0.08
3	0.03	0.03	24	0.08	0.09
4	0.03	0.04	26	0.08	0.09
6	0.04	0.05	28	0.08	0.09
8	0.04	0.05	30	0.09	0.10
10	0.04	0.05	32	0.10	0.11
12	0.05	0.06	34	0.13	0.14
14	0.05	0.06	36	0.13	0.14
16	0.06	0.07	38	0.14	0.15
18	0.06	0.07	40	0.15	0.16

Allow 0.03 min. for picking up one piece
Allow 0.02 min. for placing piece on truck
Allow 15 per cent for fatigue or rest

ASSEMBLING

There are two distinct types of furniture assembly, unit and continuous. The unit type is found in a great many of the older factories. A team of from one to three men receive the stock, machine it, drive up the unit assemblies, and finally assemble the completed units. This necessitates vast quantities of stock and unit assemblies on the floor at one time and when the final assemblies are made, a large quantity of finished product accumulates in a comparatively short period. This results in continual congestion such as that shown in Figure 97, which represents natural conditions in a certain chair factory.

The continuous process receives stock at one end of the department and a large crew of assemblers assemble it part by part progressively until at the outgoing end of the department the assembled product is inspected and sent to the finishing department. This is both more logical and economical, and reduces the volume of work in process tremendously in the assembly department.

In setting rates for assembly work, rates for each type of work on certain classes of product may be worked out as follows.

FIGURE 97.—Accumulation of Stock in Final Assembling Operation

BONUS RATE FOR BOLTING BACK, SEAT AND LEGS

Rate Symbol

DC-8

Specifications

The chairs covered by this rate are:

2988–6	2991–6U	3080–6UB	3072–6U
2974–6U	2990–6U	3069–6U	2971–6U
2994–6U	2972–6U	3073–6U	2933–6U
5959–6U	3802–6U	2985–6U	2940–5U
2899–6U	3075–6U	3079–6U	2940–6U
2995–6U	2928–6U	2993–6U	2970–6UB
2930–6U	3065–6U	3081–6U	2973–6UB
2992–6U	3078–6U	2977–6UB	2974–6UB

Time allowance per 100 pieces = 1.57 hours.

Description of Operation

The two operators stand at the vise with a pile of frame seats behind them and a pile of backs behind them at their right. While one operator is taking a seat from the pile and places it in the vise the second operator takes a back from the pile and fits it to the seat. Each operator then places one bolt and nut in position and one leg with a bolt and nut in position. They then take socket wrenches and each one tightens two nuts. The chair is then taken from the vise and placed on a pile.

From observation of the above operation it was found advisable to divide it into the following elementary units:

	Detail Operation	Unit Time, Minutes
A	Take back and seat, place in vise and fit together	0.10
B	Place bolts and nuts in position	0.16
C	Place leg in position with bolts and nuts	0.14
D	Take socket wrench, tighten two nuts	0.14
E	Tighten two nuts, lay down wrench	0.14
F	Take chair from vise, place on pile	0.16
	Total time necessary	0.85
	10 per cent for rest and delays	0.09
	Total time allowed	0.94 min. or 0.0157 hr

Bonus

In figuring a man's pay, multiply the number of 100 pieces by time allowance which gives the time allowed. The time allowed divided by time taken gives the man's efficiency. Reference to the bonus curve for this efficiency gives the percentage that the man is to receive. For instance, if he is 100 per cent efficient, his bonus from the curve shows 25 per cent. In this case, if the time taken was 10 hours, the man would be paid for 12.5 hours, the hourly rate for all men working on bonus under this rate symbol shall be 27½ cents per hour, provided their efficiency is at least 70 per cent.

However, it is far preferable to use tabulated summation rates such as the following and work up the rates for each type of operation and class of product from Table 8.

In the application of the above times the unit operations with their correct time are determined and the times are summed up making the complete actual time per chair, expressed in minutes. Then the complete time is multiplied by one of the following con-

TABLE 8 — BONUS RATE FOR UNIT TIMES FOR OPERATIONS PERFORMED IN DRIVING-UP DEPARTMENT
(All Values are in Minutes)

Operation Number	Operation	From Bench	From Floor
1	Pick up and place work on bench	0.02 to 0.09	0.05 to 0.16
2	Pick up and place work in vise	0.02 to 0.08	0.05 to 0.12
3	Pick up and place work in press	0.03 to 0.08	0.03 to 0.08
4	Pick up and place work on horse	0.02 to 0.08	0.02 to 0.08
5	Pick up piece at hand		0.02 to 0.04
6	Pick up hammer, screw driver, wrench, breast drill, screw clamp, etc., from bench		0.03 to 0.05
7	Clamp vise		0.05
8	Clamp fixture (per eccentric)		0.02
9	Tighten screw clamp		0.05
10	Tighten press (per screw)		0.08
11	Apply glue (per hole or mortise)		0.01 to 0.04
12	Walk one foot		0.005
13	Place one bolt into position		0.05
14	Place one screw into position		0.03
15	Drive one screw		0.05 to 0.09
16	Drive one nail		0.03 to 0.06
17	Run nut onto bolt by hand		0.03
18	Tighten nut on bolt with socket wrench		0.06 to 0.10
19	Drive one bolt		0.05 to 0.10
20	Place parts into position		0.03 to 0.12
21	Fit one part to another		0.03 to 0.12
22	Press corner blocks into position (per block)		0.05
23	Drive two parts together		0.01 to 0.08
24	Drill hole		0.06 to 0.12
25	Saw (machine)		0.02 to 0.06
26	Clean (must be determined by specific study)		....
27	Hand sand (must be determined by specific study)		....
28	Reverse part on bench		0.01 to 0.05
29	Reverse part in vise		0.01 to 0.05
30	Unclamp vise		0.03
31	Unclamp press (per screw)		0.02 to 0.04
32	Unscrew clamp		0.03
33	Lay down tool, clamp, etc.		0.02
34	Pass work		0.03 to 0.06
35	Place on floor or truck		0.04 to 0.08

Per Cent for Rest and Delays	Constant	Per Cent for Rest and Delays	Constant
5	1.75	25	2.08
8	1.80	30	2.17
10	1.83	35	2.25
12	1.87	40	2.33
15	1.92	45	2.42
20	2.00	50	2.50

stants for the corresponding allowance for rest and delays to obtain the time allowed per 100 pieces expressed in hours.

FINISHING

In the very varied operations of finishing the innumerable kinds of product, the use of basic procedures is absolutely essential. The following is an illustration of a good finishing rate.

The rate selected covers the application of finish to furniture parts by dipping in tanks (See Figure 98). The finishes applied

FIGURE 98.--Dip Tanks for Finishing Furniture

include paint, varnish, stain, glue, sizing, and crude oil, all upon a large variety of work.

The operations are performed in various ways, the most common being two operators at a tank; one operator takes the part from the truck, brushes the dust from the surface in some instances and drops the part into the tank. The other operator then dips the part, and places it in the drain rack at one side, where the excess material drips off and drains back into the dip tank. After completely filling the drain rack, the one operator takes the parts from it, brushes the surface to remove the runs and drops; the other operator takes the part and places it on the truck.

This procedure is sometimes varied by employing

erator alone at one or more tanks, and in this case he performs the complete cycle of operations, dipping, placing to drain, and taking down. Two men may be employed in this manner, working independently, and performing the same operations simultaneously.

Another variation is the use of two men at one tank working semi-independently, one operator performs the dipping and placing on the drain rack throughout the job, while the other operator takes the parts down and places them on the truck.

First, an allowance is made for mixing materials and cleaning the tanks, DpMC = 60 minutes = 1 hour per day.

This allowance is made to all operators working at tanks, the material in which requires mixing at the start of work morning and noon, and cleaning down at the close of work at noon and night. This allowance is pro-rated over all the jobs worked upon during the day; 0.10 hour is allowed for cleaning and mixing for each one hour of the time consumed in the actual performance of the operation. Thus, if a time or job card is turned in with time stampings indicating that three hours were consumed on a job, 0.3 hour will be allowed for cleaning and mixing; the time which the operator is considered as being actually engaged in the performance of the operation will be three hours minus 0.3 hour or 2.7 hours.

Effect of Size

The product is classified into three classes to limit the variable effect of size upon the operation.

a = Parts 12 by 12 inches and under, or parts with an equivalent area.

b = Parts over 12 by 12 inches up to and including 24 by 24 inches or with an equivalent area.

c = Parts over 24 by 24 inches, or with an equivalent area.

Rate Symbols

Dp-1 = One or more men at one tank working independently, performing same operations simultaneously

Dp-2 = Two men at tank working dependently

Dp-3 = Two men at tank, working semi-independently, performing different operations.

Analysis

A_a = Pick up charge (parts size a handled singly) = 0.02 minute

A_b = Pick up charge (parts size *a* and *b* handled) (more than one at a time) = 0.04 minute
A_c = Pick up charge (parts size *c*) = 0.08 minute
D = Transfer charge from left to right hand = 0.04 minute
E_a = Brush dust from surface (parts size *a*) = 0.02 minute
E_b = Brush dust from surface (regular surface size class *b* and *c*) = 0.04 minute
E_c = Brush dust from surface (irregular surface size class *b* and *c*) = 0.06 minute
H_a = Drop charge in tank (size class *a*) = 0.02 minute
H_b = Drop charge in tank (parts size *b* and *c*) = 0.04 minute
J_a = Dip charge in tank (parts size *a* and *b*) = 0.04 minute
J_c = Dip charge in tank (parts size *c*) = 0.06 minute
L_a = Place charge in drain rack (part size *a* and *b*) = 0.04 minute
L_c = Place charge in drain rack (part size *c*) = 0.06 minute
N = Take charge from drain rack = 0.05 minute
O_1 = Brush runs from 1 square foot of flat-painted surface = 0.015 minute
O_2 = Brush runs from 1 square foot irregular-painted surface = 0.03 minute
O_3 = Brush runs from 1 square foot of flat-painted surface = 0.03 minute
O_4 = Brush runs from 1 square foot of irregular-varnished surface = 0.06 minute
S = Place parts on truck = 0.06 minute
U = Place sticks between layer on truck = 0.20 minute
V = Remove sticks from truck = 0.10 minute
W = Arrange trucks = 0.35 minute
z = Allowance for rest and delays = 15 per cent
d = Number of pieces picked up at one time
u = Number of pieces dipped at one time
v = Capacity of tank at one setting of truck
w = Number of square feet of painted flat surface brushed to remove runs
y = Number of square feet of painted irregular surface brushed to remove runs
e = Number of square feet of varnished flat surface brushed to remove runs
f = Number of square feet of varnished irregular surface brushed to remove runs
r = Number of pieces per layer on truck, when truck is being loaded

n = Number of pieces taken from rack and placed on truck at one time
h = Number of pieces per layer on truck, when truck is being loaded

Synthesis

t = Actual time per 100 pieces
T = Time allowed per 100 pieces

Dp-1

One or more men working independently at one or more tanks; each man dips and each man takes down, performing operations simultaneously, or one man performs all operations. Time allowed is based on one man alone performing complete operation. If two men are employed, divide time allowed by 2. Parts handled under this rate are all handled more than one at a time, and are under 24 by 24 inches or equivalent area.

$$t = 100\left(\frac{A_b}{d}+\frac{D}{d}+E_b+E_c+\frac{H_b}{d}+\frac{J_a}{u}+\frac{L_a}{u}+\frac{N}{n}+O_1w+O_2y\right.$$
$$\left.+O_3e+O_4f+\frac{S}{n}+\frac{W}{v}+\frac{U}{r}+\frac{V}{h}\right)$$

Operations always performed are A_b, J_a, L_a, N, S, W.

$$t = 100\left(\frac{0.04}{d}+\frac{0.04}{u}+\frac{0.04}{u}+\frac{0.05}{n}+\frac{0.06}{n}+\frac{0.35}{v}+\frac{D}{d}+\frac{H_b}{d}\right.$$
$$\left.+0.015w+0.03y+0.03e+0.06f+E_b+E_c+\frac{U}{r}+\frac{V}{h}\right)$$
$$=\frac{4-100D-100H_b}{d}+\frac{8}{u}+\frac{11}{n}+\frac{35}{v}+1.5w+3y+3e+6f$$
$$+100E_b+100E_c+\frac{100U}{r}+\frac{100V}{h}$$
$$T = 1.15\left(\frac{4}{d}+\frac{8}{u}+\frac{11}{n}+\frac{35}{v}+100\frac{D}{d}+100\frac{H_b}{d}+1.5w+3y+3e\right.$$
$$\left.+6f+100E_b+100E_c+\frac{100U}{r}+\frac{100V}{h}\right)$$
$$=\frac{4.60+115D+115H_b}{d}+\frac{9.20}{u}+\frac{12.65}{n}+\frac{40.25}{v}+1.725w$$

$$+3.45y+3.45e+6.90f+115E_b+115E_c+\frac{115U}{r}+\frac{115V}{h}\text{ min.}$$

$$=\frac{0.077+1.92D+1.92H_b}{d}+\frac{0.153}{u}+\frac{0.211}{n}+\frac{0.67}{v}+0.029w$$

$$+0.058y+0.058e+0.115f+1.92E_b+1.92E_c$$

$$+\frac{1.92U}{r}+\frac{1.92U}{h}=\text{hours per 100 pieces}$$

Dp-2a

Two men working dependently, handing parts from one to another. Parts 12 by 12 inches or equivalent area, and under. Parts handled singly. Production based on man who first handled parts, in both dipping and taking down.

$$t=100\left(A_a+E_a+H_a+N+O_1w+O_2y+O_3e+O_4f+\frac{W}{v}+\frac{U}{r}+\frac{V}{h}\right)$$

Operations always performed are A_a, H_a, N, W.

$$t=100\left(0.02+0.02+0.05+\frac{0.35}{v}+0.015w+0.03y+0.03e+0.06f+E_a+\frac{U}{r}+\frac{V}{h}\right)$$

$$=100\left(0.09+\frac{0.35}{v}+0.015w+0.03y+0.03e+0.06f+E_a+\frac{U}{r}+\frac{V}{h}\right)$$

$$=\left(9+\frac{35}{v}+1.5w+3y+3e+6f+100E_a+\frac{100U}{r}+\frac{100V}{h}\right)$$

$$T=1.1t\left(9+\frac{35}{v}+1.5w+3y+3e+6f+100E_a+\frac{100U}{r}+\frac{100V}{h}\right)$$

$$=10.35+\frac{40.25}{v}+1.725w+3.45y+3.45e+6.90f+115E_a$$

$$+\frac{115U}{r}+\frac{115V}{h}\text{ minute}$$

$$=0.171+\frac{0.67}{v}+0.029w+0.058y+0.058e+0.115f+1.92E_a$$

$$+\frac{1.92U}{r}+\frac{1.92V}{h}\text{ hours per 100 pieces}$$

DP-2b

Two men sorting dependently, handing parts from one to another. Parts over 12 by 12 inches, up to and including 24 by 24 inches or equivalent area. These parts are all handled singly. Production based on man who first handles, parts, in both dipping and taking down.

$$t=100\left(A_a+E_b+E_c+H_b+N+O_1w+O_2y+O_3e+O_4f\right.$$

$$\left.+\frac{W}{v}+\frac{U}{r}+\frac{V}{h}\right)$$

Operations always performd are A_b, H_b, N, W.

$$t=100\left(0.04+0.04+0.05+\frac{0.35}{v}+0.015w+0.03y+0.03e\right.$$

$$\left.+0.06f+E_b+E_c+\frac{U}{r}+\frac{V}{h}\right)$$

$$=100\left(0.13+\frac{0.35}{v}+0.015w+0.03y+0.03e+0.06f+E_b\right.$$

$$\left.+E_c+\frac{U}{r}+\frac{V}{h}\right)$$

$$=13+\frac{35}{v}+1.4w+3y+3e+6f+100E_b+100E_c$$

$$+\frac{100U}{r}+\frac{100V}{h}$$

$$T=1.15\left(13+\frac{35}{v}+1.5w+3y+3e+6f+100E_b+100E_c\right.$$

$$\left.+\frac{100U}{r}+\frac{100V}{h}\right)$$

$$=14.95+\frac{40.25}{v}+1.725w+3.45y+3.45e+6.90f+115E_b$$

$$+115E_c+\frac{115U}{r}+\frac{115V}{h} \text{ minutes}$$

$$=0.25+\frac{0.67}{v}+0.029w+0.058y+0.058e+0.115f+1.92E_b$$

$$+1.92E_c+\frac{1.92U}{r}+\frac{1.92V}{h}=\text{hours per 100 parts}$$

Dp-2c

Two men working dependently, handing parts from one to another. Parts over 24 by 24 inches, or equivalent area, and are all handled singly. Production based on man who first handles parts, both in dipping and taking down.

$$t=100\left(A_c+E_b+E_c+H_b+N+O_1w+O_2y+O_3e+O_4f\right.$$
$$\left.+\frac{W}{v}+\frac{U}{r}+\frac{V}{h}\right)$$

Operations always performed are A_c, H_b, N, W.

$$t=100\left(0.08+0.04+0.05+\frac{0.35}{v}+0.015w+0.03y+0.03e\right.$$
$$\left.+0.06f+E_b+E_c+\frac{U}{r}+\frac{V}{h}\right)$$

$$=100\left(0.17+\frac{0.35}{v}+0.015w+0.03y+0.03e+0.06f\right.$$
$$\left.+E_b+E_c+\frac{U}{r}+\frac{V}{h}\right)$$

$$=17+\frac{35}{v}+1.5w+3y+3e+6f+100E_b+100E_c$$
$$+\frac{100U}{r}+\frac{100V}{h}$$

$$T=1.15\left(17+\frac{35}{v}+1.5w+3y+3e+6f+100E_b+100E_c\right.$$
$$\left.+\frac{100U}{r}+\frac{100V}{h}\right)$$

$$=19.60+\frac{40.25}{v}+1.725w+3.45y+3.45e+6.90f+115E_b$$
$$+115E_c+\frac{115U}{r}+\frac{115V}{h} \text{ minutes}$$

$$=0.327+\frac{0.67}{v}+0.029w+0.058y+0.058e+0.115f$$
$$+1.92E_b+1.92E_c+\frac{1.92U}{r}+\frac{1.92V}{h} \text{ hours per 100 pieces}$$

Dp-3

Two men at one tank working semi-independently, one takes parts, dips, and places on drain racks, while the other is taking parts from drain rack, brushing runs, and placing on truck. Production based on man who performs dipping operations. Parts handled are all under 24 by 24 inches or equivalent area, handled more than one at a time.

$$t=100\left(\frac{A_b}{d}+\frac{D}{d}+E_a+E_b+E_c+\frac{H_a}{d}+\frac{H_b}{d}+\frac{J_a}{u}+\frac{L_a}{u}+\frac{V}{h}\right)$$

Operations always performed are A_b, J_a, and L_a.

$$t=100\left(\frac{d}{0.04+D+H_a+H_b}+\frac{u}{0.04}+\frac{u}{0.04}+E_a+E_b+E_c+\frac{V}{h}\right)$$

$$=100\left(\frac{0.04+D+H_a+H_b}{d}+\frac{0.08}{u}+E_a+E_b+E_c+\frac{V}{h}\right)$$

$$=\frac{4+100D+100H_a+100H_b}{d}+\frac{8}{u}+100E_a+100E_b$$
$$+100E_c+\frac{100V}{h}$$

$$T=1.15\left(\frac{4+100D+100H_a+100H_b}{d}+\frac{8}{u}+100E_a+100E_b\right.$$
$$\left.+100E_c+\frac{100V}{h}\right)$$

$$=\frac{4.60+115D+115H_a+115H_b}{d}+\frac{9.20}{u}+115E_a+115E_b$$
$$+115E_c+115\frac{V}{h} \text{ minute}$$

$$= \frac{0.077 + 1.92D + 1.92H_a + 1.92H_b}{d} + \frac{0.153}{u} + 1.92E_a$$

$$+ 1.92E_b + 1.92E_c + \frac{1.92V}{h} \text{ hours per 100 pieces}$$

Basis of Shop Practice

For each and every phase of the manufacturing procedure, definite scientifically devised standards of operational practice should be created, based upon careful study. Not only should production standards of quantity and quality be developed in this manner, but standards of method as well. Nothing should be left to personal preference. Each operation should be performed in as near the "one best way" as possible to determine.

It is to be regretted that there has been so little research along lines which would create such woodworking standards. In the next chapter we will consider what little data are available as to the proper cutting of wood.

CHAPTER IX

THE CUTTING OF LUMBER

THE real cause of the lack of standardization in the woodworking industry can be traced to the lack of knowledge of the fundamental principles upon which the industry is based. In no instance is this more marked than in the lack of knowledge of the theory of the cutting of wood.

In the metal-working industry the cutting of metal has been the subject of study and research for many years, and the development of high-speed tool steel in its many varieties and the operation of machine-tools in general is based upon scientific fact.

Such fundamental methods, however, have been little considered in the woodworking industry. Ask any experienced woodworker what the difference should be between feed speeds for cutting oak and birch and you will probably solicit not only contemptuous pity at your ignorance or lack of "experience" but you will be met by a frank statement that "wood is wood" and you "cut it as fast as you can."

That this same lack of knowledge is prevalent among the makers of woodworking machinery is demonstrated by the following abstracts from letters requesting the proper speed and feed for woodworking bits. A large drill manufacturing company with an international reputation answers the author's inquiry as follows: "In reply to your letter of .... would say that in general the proper revolutionary speed for use in woodworking bits in various kinds of lumber is as great as possible without burning the drill. Speeds from 1000 to 2000 R.P.M. are used. This company has no official recommendation as to the proper speeds and feeds for woodworking bits except as above stated, run them as fast as possible. The most important point in boring wood is to see that the chips clear as readily as possible. This will require that a slower speed be used on deep holes than on shallow holes."

A firm specializing in the manufacture of woodworking machinery writes as follows: "In regard to bits—these should be run from 4000 to 5000 revolutions per minute." Another large woodworking machinery manufacturing concern states "spindles on the boring machines from 1000 to 3800 revolutions per minute depending upon the size of bit and style of the machine." One small tool manufacturer however very frankly covers the subject as follows: "We are sorry that we are unable to advise you in the matter mentioned in your letter of the .... We do not ourselves offer a table of speeds and feeds of woodworking bits, neither can we find any reference to this in any of the catalogues of various drill makers that we happen to have on file. Candidly, we do not believe there is one issued."

Just consider what this means. Millions of holes are being bored daily in woodworking plants throughout the country at all kinds of feeds and speeds. To any technically trained individual, the fact is evident that there is a certain maximum revolutionary speed and feed for each type of bit used in each kind of wood. To be sure, wood is not as constant a material as metal, but there are certain general fibre relations between the different varieties of wood, and through kiln drying the moisture content of the wood may be controlled.

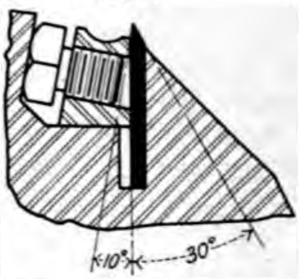
Furthermore, the metal-working industry has shown the wonderful effect of the development of high-speed tool steels, and if the same study and research were applied to the development of proper tool steels for wood, as greatly increased productions could be obtained as were in metal. To be sure, the cutting time in wood bears a slight ratio to the handling time, while in the cutting of metal the cutting time usually far exceeds the handling time, but the author has observed often as high as 300 per cent variation in the cutting times of various woodworking operations which indicates that a very appreciable saving would result from the development of proper cutting speeds of wood.

As unstandardized as are boring operations as illustrated by the above, so is the operation of circular saws. The majority of circular saw manufacturers simply recommend a definite periphery travel of from 9000 to 10,000 feet per minute with the exception of a reservation that should sufficient power not be available to maintain a uniform motion at this speed, the speed should be reduced where it can be maintained at a constant. What meagre information to give the thousands of manufacturers who are operating saws!

A still further phase of this question denoting the lack of standardization is the various methods in which saws are filed or sharpened. The average mechanic in the woodworking factory who repairs and files the saws bases his methods entirely

KIND OF WOOD	KNIFE CUTS			KNIFE BEVELS		
	GREEN	AIR DRIED	KILN DRIED	GREEN	AIR DRIED	KILN DRIED
APPLEWOOD	12	14	16	10-30	15-25	20-20
ASH (CURLEY)	12	14	16	10-30	15-25	20-20
" (PLAIN)	10	12	14	0-40	5-35	10-30
BASSWOOD	9	11	13	0-40	0-40	5-35
BEECH	10	12	14	0-40	5-35	10-30
BIRCH (CURLEY)	12	14	16	5-40	10-30	15-25
" (PLAIN)	10	12	14	0-40	5-35	10-30
BUTTERNUT	9	11	13	0-40	0-40	5-35
CEDAR	9	11	13	0-40	0-40	5-35
CHERRY	10	12	14	0-40	5-35	10-30
CHESTNUT	9	11	13	0-40	0-40	5-35
COTTONWOOD	9	11	13	0-40	0-40	5-35
CYPRESS	9	11	13	0-40	0-40	5-35
ELM (HARD)	10	12	14	0-40	5-35	10-30
" (SOFT)	9	11	13	0-40	0-40	5-35
FIR	9	11	13	0-40	5-35	10-30
GUM	9	11	13	0-40	5-35	10-30
HEMLOCK	9	11	13	0-40	0-40	5-35
HICKORY	12	14	16	5-35	10-30	15-25
LARCH	9	11	13	0-40	5-35	10-30
MAHOGANY (PLAIN)	10	12	14	0-40	5-35	10-30
" (FIG)	12	14	16	5-35	10-30	15-25
MAPLE (PLAIN)	10	12	14	0-40	5-35	10-30
" (BIRDS-EYE)	12	14	16	10-30	15-25	20-20
OAK (PLAIN)	10	12	14	0-40	5-35	10-30
" (QUARTERED)	12	14	16	5-35	10-30	15-25
PINE (YELLOW)	9	11	13	0-40	5-35	10-30
" (WHITE)	9	11	13	0-40	0-40	5-35
POPLAR	9	11	13	0-40	5-35	10-30
REDWOOD	9	11	13	0-40	0-40	5-35
SPRUCE	9	11	13	0-40	0-40	5-35
SYCAMORE (PLAIN)	10	12	14	0-40	0-40	5-35
" (QUARTERED)	12	14	16	0-40	5-35	10-30
WALNUT (AMERICAN)	10	12	14	0-40	5-35	10-30
" (CIRCASSIAN)	12	14	16	5-35	10-30	15-25

No. 1.



CUTTING BEVEL = 10°
CLEARANCE BEVEL = 30°

No. 2.

ALWAYS GIVE THE CUTTING BEVEL FIRST. THEN 15°-25° MEANS 15° CUTTING AND 25° CLEARANCE BEVEL.

No. 3.

TO ELIMINATE THE CUTTING BEVEL - INCREASE THE KNIFE MARKS 50 P.C.

No. 4

WHEN PLANING STOCK LESS THAN ½" THICK INCREASE THE KNIFE MARKS 25 P.C. - LESS THAN ¼" THICK INCREASE THE KNIFE MARKS 50 P.C.

FIGURE 99.—Standardization of Planer Knives

upon his own personal opinion and it is very probable that if one hundred such individuals were assembled and asked certain fundamental questions regarding the proper repair and filing of saws that to many such questions you would obtain one hundred answers. To a large extent, this is borne out by the

various theories of saw filing which are published constantly in the woodworking journals. Such development of the proper sharpening of woodworking tools as the theory of lip clearance developed for metal drills has never been considered so far as the author has been able to discover.

One exception to this lack of standardization is shown in Figure 99. This concern has carefully worked out the proper cutting ratios for its planers on the different kinds of woods.

In a well-known engineering text book, the mathematical theory for figuring the pitch of teeth, speed ratios, cutting resistance, feed resistance, etc., of saws is given, but in investigating a large number of woodworking industries the author has been unable to discover in any one of these plants where any member of the organization had heard of such theory or made any use of it. To illustrate the lack of standard practice in the operation of woodworking machinery, Table 9 has been prepared. It shows certain statistics gathered in six different woodworking

TABLE 9—DATA SHOWING LACK OF STANDARDIZATION IN WOODWORKING MACHINERY

	A	B	C	D	E	F
Cut-off Saws:						
Diameter, inches.........	18	20	16	18	20	14
Revolutions per minute....	2200	1900	2200	2200	2100	2900
Lineal feet per minute.....	10,300	9950	9200	10,360	11,000	10,650
Band Rippers:						
Saw, lineal feet per minute.	6700	.....	.....	8300	7500	8150
Feed, feet per minute.....	.....	.....	120	.....	116	135
Planers:						
Revolutions per minute...	4500	4200	3600	4500	3310	3300
Feed, lineal feet per minute	33	30	30	20	21	25
Number knives...........	2	4	4	3	4	4
Cuts per inch............	26	46	40	56	49	44
Stickers:						
Feed, lineal feet per minute.	70	35	20	.....	53	14
Continuous Jointers:						
Feed, lineal feet per minute.	.....	45	36	.....	32	.....
Shapers:						
Revolutions per minute...	4500	4300	.....	8430	5860	6000
Band Saws:						
Lineal feet per minute....	6300	.....	.....	.....	5100	6150
Sand Drums:						
Lineal feet per minute.....	3825	3600	.....	.....	4570	.....
Sand Belts:						
Lineal feet per minute....	2010	3000	3170	4000	2815	2280

plants by the author, the various plants being designated as A, B, C, D, E, and F. It should also be noted that these six factories were manufacturing the same type and grade of product with very similar equipment, and using practically the same varieties of wood.

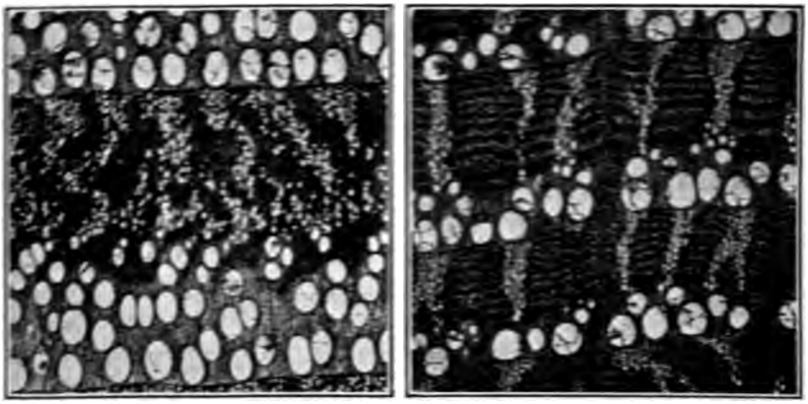


FIGURE 100.—Micro Structure of Coarse-Fibred Wood

For several years the author has endeavored to formulate a theory for the cutting of various types of hard wood. The basis

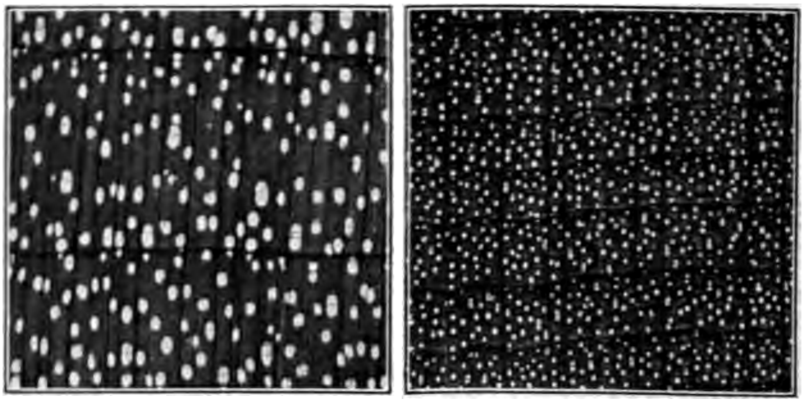


FIGURE 101.—Micro Structure of Fine-Fibred Wood

for this has been time study and observation of various types of tools and equipment operating upon various types of wood. The results are very meagre as yet, inasmuch as the cutting steel or tools were simply local equipment and this important factor of the problem had, of necessity, to be practically ignored. The author

does not feel justified in publishing any definite figures on this subject inasmuch as it has been impossible to pursue these investigations in a thoroughly scientific manner but in general the theory may be stated as follows.

For coarse-grained woods such as oak a relatively high cutting speed with a slow feed should be used, while for fine grained such as birch a slower cutting speed with a faster feed should be used.

These facts were established by actual experimentation and in examining the results for the probable basic theory it would seem that the cutting speed was largely dependent upon the cutting or shearing of the individual fibres of the wood. That is, that where there were many small closely grained fibres, of necessity the cutting speed must be reduced as more fibres present themselves to the saw or tool, but inasmuch as these fibres are smaller, a greater feed could be maintained, while with large-fibred wood such as oak, fewer fibres are encountered, hence the speed of the tool can be greatly increased, but due to the resistance of the larger fibre a slower feed must be used.

Coarse-fibred and fine-fibred woods are shown in cross-section in Figures 100 and 101 respectively. It will be noted that the pores (the large white spots in the figures) in the coarse-fibred woods are less evenly distributed than in the fine-fibred woods. This is occasioned by the fact that these grow larger in the beginning of each annual ring—springwood—and decrease as the season advances—in the summerwood. It is the author's belief that this irregularity of texture, requiring the tool to alternately cut coarse and fine layers, is responsible to a large degree for the slower feed required by coarse-fibred woods, the areas of more pulpy springwood allowing the higher revolutionary or peripherial speed to be maintained. In the fine-fibred woods the more even texture allows a higher feed to be used, but the constant firmness of texture reduces the peripheral or revolutionary speed.

The above applies only to the porous or so-called hardwoods as these are the types most commonly used in the plants where the author's experiments were conducted. The conifers or non-porous woods, mostly soft, practically allow any speed mechanically possible to attain to be used. The real requirements of cutting theory of wood are practically limited to the porous or hardwoods.

To establish such fundamental methods a large woodworking

company, or better an association of one of the many branches of the woodworking industry, should appropriate a fund for scientific research along these lines. The investigation should be carried out by engineers not only experienced in the practice of woodworking but also who have been trained along the lines of scientific management and can be depended upon to carry out the necessary experiments upon a purely scientific non-prejudiced basis. Such experiments would require co-operation with the manufacturers of woodworking tools to determine the best types of steel for the various principal varieties of wood upon all major operations such as sawing (both cross-cutting and splitting), planing, boring, turning, slotting (mortising or tenoning), etc.

The proper relation between peripheral speed and feed should be established for each type of tool and operation on each kind of wood, careful consideration being given to the fundamentals indicated by the actual results of the experiments. A very careful study of the structure and properties of the various types of wood and the influence of moisture-content upon speed should also be made. It is the firm belief of the author that such investigation would practically revolutionize the woodworking industry not only from the greatly increased efficiency of cutting operations developed therefrom, but also introducing a general appreciation of the value of standards in the conduct of the woodworking industry which is so sadly lacking at the present time. In order to bring to the attention of the woodworking executive who may read this chapter the value of such theory as exists at the present time on this subject, the following formulae are quoted from Pages 1463 and 1464 of Marks Mechanical Engineer's Handbook.

Notation

h = Thickness of cut, inches
H = Stroke of gang saw, inches
t = Pitch of saw teeth, inches
s = Thickness of blade, inches
u = Peripheral speed of blade, feet per minute
n = Revolutions per minute
f = Feed per minute, inches
f_1 = Feed per stroke, inches
D = Diameter of circular saw blade or band saw wheel, inches

L = Free length of gang saw blade, inches
P = Cutting resistance, pounds

Pitch of Teeth in Saw Blades

For solid blades with set teeth, $t = 0.97kh$, and for swages or inserted teeth cutting their full width, $t = 1.38kh$. For band saws, $k = 0.02$ to 0.1; for gang saws, $k = 0.08$ to 0.4; for circular saws, $k = 0.1$ to 0.6.

Speed-feed Ratios for Saws

For maximum permissible rate of feed the following relation holds: $f/u = f_1/H = 0.0072(f/h)$.

For heavy circular saws for logs.............	$f/u = 0.00083$	to 0.000083
For circular rip saws......................	$f/u = 0.00023$	to 0.000047
For fine-toothed circular saws................	$f/u = 0.000083$	to 0.000012
For heavy band saws for logs................	$f/u = 0.00023$	to 0.000023
For gang saws............................	$f_1/H = 0.03$	to 0.003
For veneer saws..........................	$f_1/H = 0.002$	to 0.0005

Cutting Resistance

The cutting resistance of a saw in pounds $= P = Cshf/u = Csf_1$, where $C = 1{,}200{,}000$ to $2{,}900{,}000$.

Resistance to Feeding

For circular saws, resistance $= 1.25P$; for gang or band saws, resistance $= P$, where P = cutting resistance, pounds. The force (pounds) required to feed a log to a circular saw (including that required to move the timber carriage and the log) $= 0.006W + 1.25P$, where W = weight of log, pound; for a band or gang saw, force $= 0.006W + P$.

Power Requirements of Saws

The horsepower required by a saw $= N = N_0 + N_1$; where N_0 = horsepower required to overcome the friction of the machine, and N_1 = horsepower expended in cutting. In the following formulæ b = width of saw cut, inches, and F = area (length cut × thickness of lumber) cut per hour, square feet.

For Circular Saws

$$N = \frac{nD}{32{,}000} + \frac{2.36bF}{(14 \text{ to } 28)}$$

For Band Saws

$N_0 = 0.3$ horsepower (up to 9 horsepower for large log saws):

$$N_1 = \frac{37 + 0.01b(u/f)}{10{,}764} F \text{ for pine}$$

For oak, substitute 52 for 37 and 0.0124 for 0.01. For red beech, substitute 62 for 37 and 0.0148 for 0.01.

For Gang Saws

$N_0 = 0.25$ to 3 horsepower:

$$N_1 = \frac{46 + 5.7b(H/f_1)}{10{,}764} F \text{ for air-dry pine}$$

According to Hermann's investigations, for gang saws with freshly sharpened teeth,

$$N_1 = K\left[1 + \frac{b + 0.118}{t}\left(4 + \frac{H}{100f_1}\right)\right]F$$

where $K = 1/215$ for pine, $1/161$ for fir, and $1/147$ for deciduous trees. After z hours of operation the value of N_1 should be multiplied by $(1 + 0.145z - 0.005z^3)$.

According to Dodge, for circular rip saws running at from 7000 to 9000 feet per minute, horsepower (approximate) $= D^2/40$, and for band saws running at 3500 feet per minute, horsepower $= D^2/300$.

CHAPTER X

LABOR CONTROL

THE usual method of employing labor in a woodworking industry is for applicants to be interviewed by the shop superintendent, or in many cases by the foremen, who hire the men upon personal estimate and judgment rather than upon any previously determined required characteristics, and sets the remuneration according to some standard laid down by the management. This, of course, is the old traditional method employed in all businesses up to comparatively recent times.

As soon as the standardization of the manufacturing processes, consisting principally in motion and time study, has taken place, the type of operative required for the various operations is definitely determined and recorded, and new operatives should be selected to meet such requirements. Furthermore, the remuneration for each process is definitely set by such standardization. With these fundamentals available, the establishment of an Employment Department is simple and the value of such division of function is to-day practically accepted in the manufacturing world.

In a small woodworking plant of one or two hundred people it is practically impossible to allow one individual to devote his entire time to the Employment Department, but in all plants of three hundred employees or more this is entirely feasible. Furthermore, in the smaller plant this function may be taken care of by a special individual who, however, devotes a certain percentage of his time, say half, to certain other duties. The function of the Employment Department is not only that of procuring the help required, but is to maintain the necessary records of all employees, and through general oversight obtained from these records to bring to the attention of the management plans for keeping the labor overturn at a minimum and promoting satisfaction among the employees through co-operation with the plant nurse.

In a small woodworking plant the phase of social service, which is of course very closely allied with the employment function, can usually be taken care of by the employment manager and a well-selected nurse. In any plant of over a hundred employees the effectuality of labor can be greatly assisted by maintaining proper medical supervision over the employees, and in the small plant this can be best carried out by the employment of a

REQUISITION FOR HELP

USE ONE SHEET FOR EACH OPERATIVE DESIRED

DEPT.__________

DATE__________

PLEASE HIRE TO START WORK

ON____________________
DATE & HOUR

A____________________ FOR WORK
MAN, BOY, WOMAN

ON RATES____________________
SYMBOLS OF RATES

SIGNED____________________
FOREMAN

APPROVED____________________
SUPERINTENDENT

DETACH AND FORWARD TO PAYROLL

NAME____________________

DEPT.__________ WILL START__________

HOURLY OR WEEKLY RATE____________________

SIGNED____________________
EMPLOYMENT MANAGER

FIGURE 102.—Form for Requisition for Help

nurse. When possible, the nurse should also have been trained along social service lines in order that she can maintain not only the function of health supervision and attention to accidents, but also social service. In large plants, of course, a resident physician and a bona-fide social worker will be found good investments.

PROCUREMENT AND REGISTRATION OF EMPLOYEES

When a department requires additional employees a requisition similar to that shown in Figure 102 will be made out, and

after its approval by the Shop Superintendent if it is for factory operatives, or by the Office Manager if it is for clerical employees, it will be forwarded to the Employment Manager.

In the Employment Department will be maintained a complete card index of the general requirements for operatives for each

NAME SHOP NO.

ADDRESS

DATE OF BIRTH CIVIL STATE

NATIONALITY PLACE OF BIRTH

EXPERIENCE

FIRM	FROM	TO	OCCUPATION	REASON FOR LEAVING	WAGES

FIGURE 103.—Form to be Filled in by Applicant for Work

Date........................

I agree to give the [redacted] Company at least one week's notice before leaving their employment, or forfeit all money due to me for wages upon failure to give such notice.

Signature of Applicant..

Date of Employment..

Department..

....Foreman

FIGURE 103—Continued.—Reverse of Form for Application for Work

position connected with the business. These requirements are not necessarily strict, but are the general influencing characteristics required for an individual to satisfactorily fill the various positions. For instance, for a lumber handler in the lumber yard these requirements would probably be for a man not less than 5 feet 10 inches in height, weighing not less than 170 pounds, and of the physical rather than the mental type, who could make simple additions, subtractions and notations on the yard records; while for a billing clerk in the office, the charac-

teristics required would be for a woman of the nervous energetic type not over a certain age who has had experience in operating a certain billing machine. In other words, the file of require-

Date of Employment
Department
Name
Address
Age Height Weight Condition Living with

VISION
Distant R. L.
Reading R. L.
Correction Record

HEARING
Conversation R. L.
Distant R. L.
Correction Record

MASTICATION

Lungs
Respiration
Throat
Stomach
Bowels
Nervous System
Skin
Disabilities
Correction Record

CONTAGIOUS DISEASES
Mumps
Measles
Scarlet Fever
Typhoid

VACCINATIONS
Smallpox
Typhoid

Correction Record

GENERAL CONDITION

Color
Texture
Vitality
Fingers
Arm Length
Limb Length
Mentality
Appearance
Dress
Character
Education
Comprehension
Likes and Dislikes
Special Characteristics

A. E. B. Number
English Knowledge
Nationality
Denomination
Aptitude Shown During Employment
Skill
Reliability
Ambition
Intelligence
Causes of Personal Inefficiency

Most Suitable Employment
1st Choice
2nd Choice
3rd Choice
STANDARD PERSONAL EQUIPMENT
LEFT EMPLOYMENT
Date
Reason
New Occupation
Desirable
Undesirable
PROMOTIONS AND ADVANCEMENTS

FIGURE 104.—Reverse of Form for Employment Department's Permanent Record for Employee

ments should show the Employment Manager just the type of person he has to obtain for each position. His function is then to obtain individuals *as near* these requirements as possible.

The first function of employment is the filling out of the

application shown in Figure 103 by the applicant. In many concerns it is the practice to have the applicant fill out a very com-

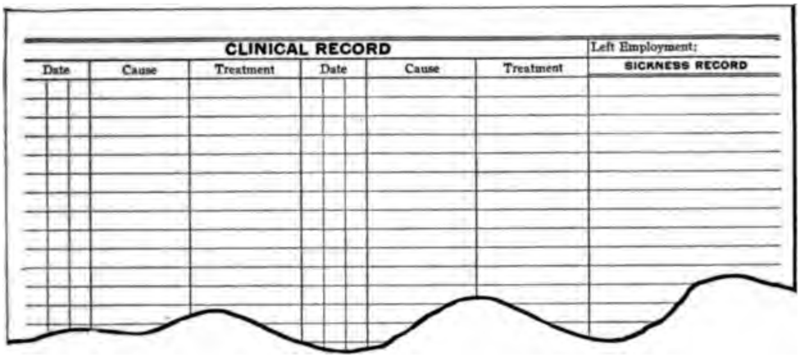


FIGURE 105.—Form for Clinical Record of Employee

plete application form, but in the small woodworking plant this is not deemed essential as the complete details regarding the op-

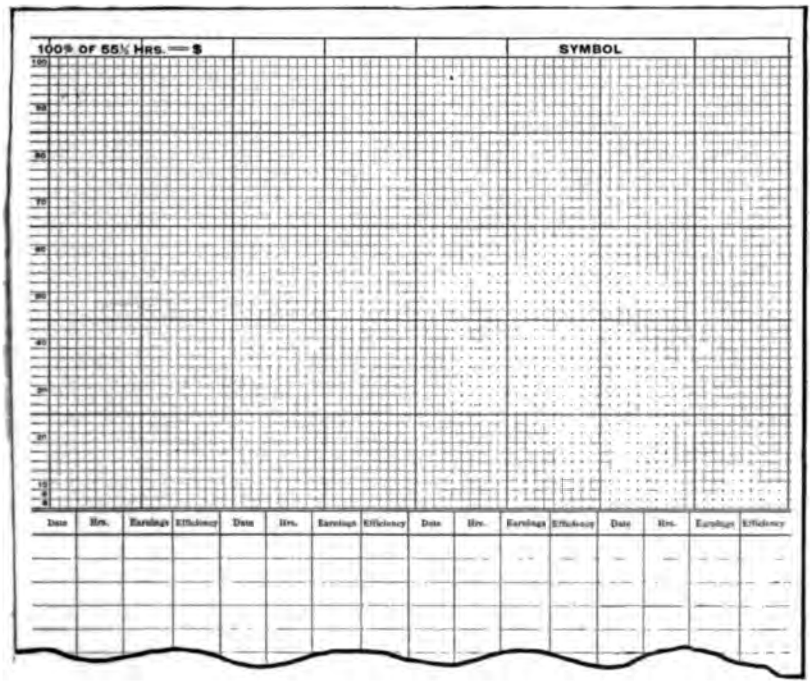


FIGURE 106.—Form for Permanent Employment Department's Record of Employee

erative are obtained later. After the applicants have filled out an application blank, they will be sent to the nurse, where the

form shown in Figure 104 is filled out. This form is printed on fairly heavy cardboard, the clinical record being continued on the back of the form as shown in Figure 105. The upper part of the form covering the previous health record of the employee is also printed on thin paper. The thin-paper form is made out during the examination with a carbon between in order that an exact duplicate is shown on the cardboard record.

In a small plant such an examination is usually made by means of conversation between the nurse and the applicant, while in larger plants it is possible to have an actual examination made by a physician. The paper original of the examination is

Service Investigation

DEPARTMENT	LEFT SERVICE	INTENDS TO LEAVE	FOLLOW-UP DATE
Finishing		6/12-18	6-20-18
NAME [illegible]			~~6-30-18~~
ADDRESS 415 [illegible]			7-2

REASON Earnings too small.

PROCEDURE OF FOLLOW-UP Report her to Mr Pfeifer have him investigate to try & satisfy her. Reported to Mr Pfeifer.

FIGURE 107.—Form for Record for Service Investigation by Nurse

then given to the applicant to take back to the Employment Department, where, if the applicant's examination is satisfactory, the data will be copied on to the upper half of a form similar to Figure 109, which is the Employment Department's record of the applicant, and the lower half of this form filled out. The back of the Employment Department record is shown in Figure 105. It will be noted that space is provided for a graph at the top of the back of this form, and at the bottom columns are provided for showing the earnings and average efficiency of the operative. Each week the workmen's records shown previously in Figure 61 are sent to the Employment Department, and the efficiency and earnings of each operative recorded and plotted. In this manner the Employment Manager can watch the progress of each individual, and as soon as an operative's efficiency or earnings begin to decrease, the Employment Manager notifies

DAILY NURSE REPORT DATE ______ 19__

NAME	TREATMENT	Abrasions	Boil	Bruise	Burns	Cold	Constipat'n	Cramps	Cuts	Dental Trouble	Earaches	Epilepsy	Eyestrain	Eye—Foreign Sub.	Grippe	Headache	Hysteria	Indigestion	Infection	Nail Puncture	Neuralgia	Nose Bleed	Re-Bandage	Sore Throat	Sprain	Stomach'he	Stye on Eye	Sun Burn			Home Calls	Sent Home	Sent to Hospital	Sent to Physician	Sent to Dentist	Glasses Fitted	Employment Examinat'n	

FIGURE 108.—Form for Nurse's Daily Report

Week Ending	Dept.	EMPLOYEES LEAVING																					EMPLOYEE'S ENTERING																			
		American	British	Latin	Slav	Saxon	Male	Female	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	House Work	Stores	Others	Leaving Town	Marriage	Health	Incompetibility	Dissatisfied	School	American	British	Latin	Slav	Saxon	Male	Female	Coopers	Nash	Simmons	Badger	Am. Brass	House Work	Stores	Home	School	Others	Out of Town	B.C.	Total Employes

FIGURE 109.—Form for Weekly Service Report of Employment Department

the Shop Superintendent and Planning Chief in order that a remedy may be applied before the employee becomes dissatisfied. The result of such control of the employees is that dissatisfaction rarely arises as the management is given an opportunity to correct any cause of dissatisfaction before it becomes serious.

Any employees absent are investigated by the nurse, she calling at their homes and making out a service investigation form as shown in Figure 107. When hospital treatment or dental treatment are necessary, she arranges for this after consultation with the Employment Manager or in very serious cases, after consultation with the General Manager. In other words, it is her duty to do everything in her power to maintain the health of each and every employee as well as assisting in maintaining their satisfaction as outlined below.

The nurse is constantly in touch with the physical condition of the employee, maintaining the clinical record shown in Figure 105. Each day the nurse makes out the report shown in Figure 108 which is forwarded to the Employment Manager in order that the health of the various employees constantly receives his attention. This report is summarized on another similar report monthly, serving as a permanent record.

In addition to this supervision of the earnings and health of the employees, as soon as any operatives indicate to their foremen that they desire to leave their employment, the foreman makes out a service investigation card similar to that shown in Form 107, and forwards it to the Employment Manager. If he can satisfy the employee he does so, making a record of the transaction, but if the operative has already left, he or the nurse calls at the home of the operative to investigate the case and to endeavor to get the employee back to work. A record of such investigation is made on the service investigation card by the Employment Manager or nurse, together with suggestions as to future procedure under the title Procedure of Follow-Up. These service investigation cards are then returned to the Employment Department where a weekly sheet shown in Figures 109 and 110 is made out. As noted in Figure 109, the employees leaving are summarized according to nationality, other employment to which they are going, and miscellaneous reasons. The employees entering are summarized according by practically the same reasons.

On the reverse side of this form shown in Figure 110 a complete summary of labor conditions is given, together with a

résumé of the service investigation made on these cases. This report, together with the nurse's reports, hould be weekly given very careful scrutiny by the General Manager in order that the labor overturn may be reduced to a minimum.

Various other details such as the transfer of employees from department to department, method of discharge, adjustments of wages, etc., might be described and the forms shown, but it is believed that while these are necessary mechanisms they do not

					SERVICE INVESTIGATION		
Total Employes Leaving	Total Employes Engaged	Per cent Loss of Employes	Per cent Gain of Employes	Per cent Labor Turn Over	Retained	Lost	Total

FIGURE 110.—Continuation of Form for Employment Department's Weekly Report

affect the general principles which we are trying to develop herewith, sufficiently to be shown.

TIME STUDY

In the art of installing scientific management, no principle is so basic as that of fairness. In fact, it is the only factor that can never be deviated from if you are to be successful. The first requisite for fairness is knowledge. Ignorance always leads to unfairness. Time study gives us knowledge of the necessary time element and is, therefore, a fundamental factor in the art of securing a fair remuneration for the workmen. As the method of remuneration is often the principal influencing factor in the successful installation of scientific management, we realize that time study is one of the fundamentals of the science, or rather of the art of installing the science.

Furthermore, in order to obtain maximum production in any industrial plant, it is necessary that work be planned for the various operations in advance. It is self-evident that to plan work in advance, accurate knowledge must be at hand as to the time required for each step in the manufacture of the product. Time study is the means by which this time element is obtained.

History of Time Study

Timing of manufacturing operations in the form of rude time studies has existed for several hundred years. In a Manor Audit of Cuxton Manor, made in England in 1540, the author has found a record of a piece rate for the sawing of logs into boards, and a statement as to the approximate number of hundred feet which should be accomplished by two men in one day. We, therefore, see that as early as the sixteenth century the time element was given consideration.

Charles Babbage in his Economy of Machinery and Manufacture, published in 1832, gives the results of an operational time study of pin making in France in 1760, quoting observations made by M. Perronet. Babbage compares these times with those for similar operations in England in 1830. The eminent French Physicist, M. Coulomb, who died in 1806, has written regarding time study, as have also several of his contemporaries of that period. M. Coulomb, however, had very little understanding of real scientific time study as he specifically recommends that observations should be made without the knowledge of the workmen. This is an improper method of making time studies and, therefore, showed that he did not have extensive experience regarding them.

Operations to Be Time Studied

The first factor for consideration in time study is whether its application is a profitable investment if applied to the operation under question. The volume of production handled by the operation is the common guide. However, a few seldom used operations should sometimes be time studied in order to provide standards for the planning department to enable the planning of subsequent operations or to guarantee standard conditions for these subsequent operations. In general, a study of the economic feasibility of a timing should be made before any direct study is made.

Kinds of Time Study

The two principal kinds of time study are total or over-all and unit time studies. The total, or over-all time study, simply observes the time required for accomplishing several units of `, then the division of this time by the number of units pro-

duced, giving as a result the average time per unit. This method is very crude, and often is more misleading than entire absence of time knowledge. One class of work, however, upon which it can be used advantageously is upon automatic machinery having a constant production; or, in other words, upon purely automatic operations into which the human factor does not intrude.

The unit time study subdivides these major operations into minor operations and, again, re-subdivides these minor operations into their details, until the entire operation is resolved into individual motions. The time observations are made upon either these unit motions or upon small groups of them if the individuals are too small to be observed. In general, no time should be observed which is under 0.02 minute or over 0.10 minute in duration. The reasons for these times are that it is practically impossible for any person to observe a motion, read the stop watch and properly record the time in less than 0.02 minute. Over 0.10 minute for a motion usually indicates that further subdivision is possible.

The unit time study is applicable to practically every type of operation, and the author believes it a profitable investment to apply it in every instance, with the exception of purely automatic machinery of the type as mentioned above, into which the personal element does not enter.

Methods of Time Study

The total, or over-all, time study is so simple that it is unnecessary to describe the method of making it in detail. It consists simply in starting a stop watch at a certain time and running it while the product is being recorded.

The method of making the unit time study, however, will be described in detail. There are two main subdivisions of this method; the first is observation and deduction and the second deduction and observation.

The observation and deduction method may be applied in three ways; first, personal observation the timing being done with one watch; second, personal observation the timing being done with two watches; third, observation by means of the photoscope or moving picture machine.

In general, observation and deduction collects all the data from the operation in the condition which the operation is found,

and then by deduction from these observations outlines the new method and times required.

When the observations are made personally and timed with one watch, the operation is first observed and the unit motions identified. The watch is then started and the time recorded for the performing of each unit operation and the time noted for all rests and delays. The watch is run continuously during the observation and every hundredth of a minute apportioned to either a unit motion or to delay. The observer then studies his data, classifies them, and eliminates the motions and the corresponding times which he considers unnecessary, and finally works out a task in the usual manner, which are described on page 215.

When personal observation takes place, the timing being done with two watches, the observation is usually made by two observers, each running a stop watch. One observes productive time and the other non-productive or delayed time. They observe the motions by units in the same manner as when one watch is used, and the task is created by deduction in the same manner.

The use of a photoscope or moving-picture machine, while applicable in larger industries, is somewhat far advanced for use in an industry as traditional as woodworking. It unquestionably records time better than personal observation can, but there seems to be a tendency in its use to make observations in too automatic a manner, losing sight of the personal or human elements. Except where a very high type of operative is encountered, which is not the case in woodworking, workmen often object to its use. Therefore, in connection with woodworking, this method of observation has not seemed applicable to the author.

Method of Deduction and Observation

Deduction and observation, the method which the author and his associates use, consists in first making a careful study of influencing conditions. These are corrected and regulated before any further progress is made. Next, the method of supply and removal of product and all influencing conditions are standardized and guaranteed. A careful motion study is then made of the operation and the proper motions determined for future performance of the operation.

After the standard motions have been determined, the engineer who is to make the time study teaches them to a work-

man, who has been carefully selected as a man to whom bonus incentive will appeal and who has the necessary physical and metal assets and who has considerable influence among his fellow workmen. Before any observations are made he is perfected in the performance of the operation in the manner prescribed. The observation is then made by means of the stop watch, studying unit motions, and recorded on some standard form of data sheet.

In Figure 111 an actual observation sheet on woodworking

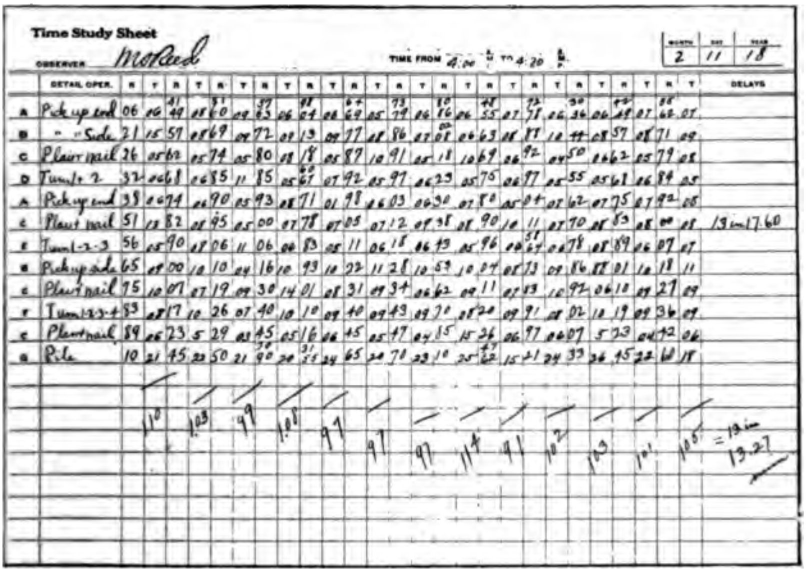


FIGURE 111.—Observatoin Sheet on a Woodworking Operation

operation is shown. The observer lists operations in the column headed Detailed Operation, and indicates the readings of the stop watch in the columns headed R, then by deducting each reading from the succeeding one the time of the operation is found and is entered in column T. Any delays coming up should be noted in the column headed Delays, together with the time that was taken out. As many such observation sheets should be made on each operation as feasible. Where the times for the various operations are found to run fairly uniform a smaller number of observations can be used than when the times are very varied, as this latter condition is more hard to summarize, and hence more time and material must be used.

Human Element

The foregoing brief description of method is misleading if it is assumed that time study can be made in such a cold matter of fact fashion as outlined. There enters into the actual time study, from the first observation of the old method to the final installation of the new task, the human element. The first phase of this requires that the workman be convinced of the fairness of the study. As mentioned before, the first requisite of fairness is knowledge. Therefore, the reason for making it, the method, and the final result of the time study must be carefully explained to the workman. He must be convinced that the proposition is to be carried out solely for the benefit of himself and his employer, that the observer believes thoroughly that to obtain valuable results, mutual gain must accrue from all such work to both the workman and his employer, that neither can be neglected if the other is to actually profit in the end.

This explanation of the purpose, method, and result of the time study, if properly made, will gain co-öperation of the workman.

In addition, however, what we call time intuition is necessary on the part of the observer, for no matter how convinced one is of the co-operation of the workman, he must constantly guard against any attempt by the workman to mislead him as to time required or to himself incorrectly gauge the time observed. It is impossible to record observation in such a manner that a second party can definitely create a task from it. The observer must be able in the creation of the task which will be outlined later to know just which unit motions should be given a little more leeway and which ones should be tightened up. The workman is probably not entirely perfect in the new method or certain conditions may not be normal and therefore, the observer must gauge the relation between the present time of operation and the probably future time. This is where the human element of the observer enters in.

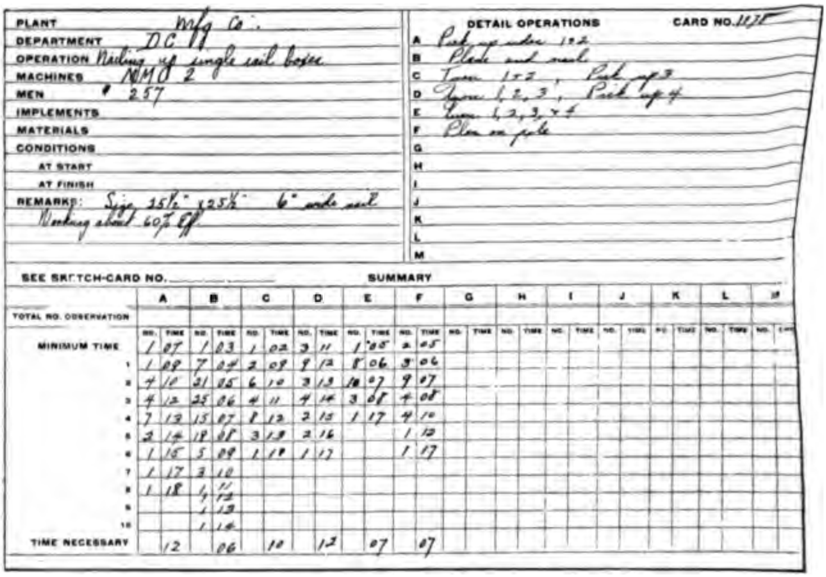
This question of human element is the greatest and most uncontrollable one that enters into time study. The author has read articles wherein time study was described as a purely mathematical proposition. Some of these articles were written by men eminent in the profession, but they were written either with the purpose of giving false assurance as to the simplicity of making time studies, or the men writing them had grown so far away

from actual time study that they had lost sight of this very important phase. Just as the real fundamental purpose of scientific management is, after cutting away everything else, methods, theories and practice, to establish the proper co-opertive relation between the employer and the employee, so in time study is it absolutely essential for the observer to so control the human element that he gains not only the co-operation of the workman, but also controls his own personal influence upon the study.

Working Up the Task

After making the time study by any of the above methods, it is next necessary to create the task. Up to this point, the work has been analytical. It is now necessary to synthesize the data so obtained into a task. The first phase of this synthesis is to carefully detail the standard conditions under which the operation is to be performed. These must define positively the method of supply, removal of material, equipment, tools, product to be worked upon, quality of product required, divisions of the task for each type of product, and carefully describe all influencing conditions, such as light, power, ventilation, etc. The actual performance of the operation, motion by motion, is then described, and to each motion is assigned the proper unit of time. This unit of time is determined by analysis of the summary of the time study. The summary of the time study is made by listing under each unit motion a table of the times in which this unit was performed during the observation. Such a summary of unit times is shown in Figure 112. The observer must select from these various times the proper one for each motion. This is done by inspection, largely influenced by the before mentioned time intuition. A rule for this has been evolved which is as follows: Eliminate all odd times, such as times which are evidently far below or far above normal. Then determine the average time and select a time half way between the minimum time observed and the average time. This, however, the author has found does not work in a large number of cases. If the operative is working in an excellent manner, without any evidence of soldiering, and if all influencing conditions are perfect, this rule will not apply because the minimum time observed will then be the proper time, while if soldiering is taking place, the average time will be far above normal. Accordingly, the rule which the author uses for selecting the proper time is to take the time near-

est the minimum observation which the observer believes to be fair. It will be seen that this is injecting the human element tremendously and eliminating the mathematical. This is granted, for, as it has been mentioned above, time study must consider the human element and must be influenced by the human element, for the reason that it is observing the action of a human being controlled by a human mind, rather than a machine. That this introduction of the human element does not mislead us, if properly applied, is proved by the fact that several thousand rates



PLANT Mfg Co.
DEPARTMENT DC 11
OPERATION Nailing up single coil boxes
MACHINES NMO 2
MEN # 257
IMPLEMENTS
MATERIALS
CONDITIONS
AT START
AT FINISH
REMARKS: Size 15½" x 25½" 6" wide nail
Working about 60% Eff.

DETAIL OPERATIONS — CARD NO. [illegible]
A Pick up sides 1 2
B Place and nail
C Turn 1 2, Pick up 3
D Turn 1, 2, 3, Pick up 4
E Turn 1, 2, 3, 4
F Place on pile
G
H
I
J
K
L
M

SEE SKETCH-CARD NO. ______ SUMMARY

	A NO.	A TIME	B NO.	B TIME	C NO.	C TIME	D NO.	D TIME	E NO.	E TIME	F NO.	F TIME	G	H	I	J	K	L	M
TOTAL NO. OBSERVATION																			
MINIMUM TIME	1	07	1	03	1	02	3	11	1	05	2	05							
1	1	09	7	04	2	09	9	12	8	06	3	06							
2	4	10	21	05	6	10	3	13	10	07	9	07							
3	4	12	25	06	4	11	4	14	3	08	4	08							
4	7	13	15	07	8	12	2	15	1	17	4	10							
5	2	14	18	08	3	13	2	16			1	12							
6	1	15	5	09	1	18	1	17			1	17							
7	1	17	3	10															
8	1	18	1, 1	11, 12															
9			1	13															
10			1	14															
TIME NECESSARY		12		06		10		12		07		07							

FIGURE 112.—Summary of Unit Times Determined by Analysis of Time Study Observations

set during the last seven years, under the author's supervision, with the exception of less than a small fraction of one per cent, have worked satisfactorily and are still working to-day, and have resulted in very material reductions in labor cost.

The mere selection of the individual times is not the complete task. These times must be joined by substitution in an equation in order to give the task a simple mathematical solution. For instance, if a motion occurs once, it is self-evident that this unit of time is included in the equation but once. If the motion happens but once per hundred units of product but one hundredth of this unit must enter into the equation, while a motion occurring three times per unit of product must enter into the equation

three times. Then with the solution of this equation giving the total actual time for performing a unit or a definite number of units of work at hand, we must next make the necessary allowances for rest to overcome fatigue.

Allowances is a subject in itself. The setting of these allowances requires intricate, careful observation and deduction. The subject of time allowances has been very carefully developed by Messrs. Carl Barth and Dwight C. Merrick, and it is therefore unnecessary for the author to cover it at this time.

This knowledge is classified in such a manner that, knowing the type of operation and product the proper percentage allowance for fatigue can be applied directly. Regarding necessary delays, it is the author's practice to allow at least 10 per cent and often 25 per cent additional time for the occurrence of things beyond the control of the workman or the planning department. With the addition of these percentages for delays and fatigue, the final task is obtained.

Regarding fatigue, it might be well to remark that it is often necessary to provide definite rest periods of certain duration at certain intervals during the day, rather than a percentage. This is very necessary when work requires extreme physical strain or fatiguing mental application.

It is also necessary to include in the task a description of the manner in which cost and production data for the operation are to be obtained.

Collection of Production Data

This collection of production pay basis and cost data should be carried out by automatic devices whenever possible. Their design calls for the greatest ingenuity as they must be not only fool-proof and accurate, but must not be susceptible to increase in readings by artificial means. Often a carefully worked out equitable basis of payment must be abandoned either because the data cannot be collected economically or because the only possible collection method could be readily tampered with by the operative.

To summarize, the basis of production data and payment must satisfy the following conditions:

a Pay the workman in preportion to his effort
b Absorb cost satisfactorily
c Provide incentive to workman to maintain quality

d Provide incentive to workman to maintain maximum production

e Eliminate variable conditions

f Be easily determined, preferably automatically

g Not susceptible to falsification

Comparison of Cost

It is also an invaluable policy to figure the old cost of an operation and the cost of the operation performed under the created task, figuring the resultant saving. Especially to an inexperienced time-study man is this phase valuable, because he will sometimes find that his evolved method will cost more than the old method. This is not necessarily a criticism of his rate, however, as the old method may have resulted in poor quality of product or over-strain of operative, both of which in the end are uneconomical.

Installation

The actual installation of the task requires still more application of the human element. It is absolutely necessary that the time-study man or observer should be able to demonstrate, if necessary, the feasibility of his task. No man is fitted for an observer who has not had sufficient manual and machine experience to be able after the careful observation of an operation to perform it himself in the manner in which he believes it should be carried out and at a reasonable rate of speed. Actual demonstration of the practicability of the rate is often the only way in which the co-operation of the workman can be obtained. The installation should also be accomplished by over-all time study recording the definite performance of the task within a stated time, such as shown in Figure 113. This record should be taken for at least one complete day and in all cases until the operative reaches at least 80 per cent efficiency and dated and signed by the observer, showing that the workman has actually been taught to perform the operation within the time prescribed and has done so with a satisfactory result. It often occurs that conditions governing an operation are changed after the time-study man has left the operation, resulting in failure of the operative to perform his task. A dated and signed statement, showing that a certain man has actually performed the operation at specified time will often force the management to recognize the practicability of the rate and reinstate standard conditions.

Basic-Time Studies

If it were necessary to motion and time study the handling of each item of product on every operation the cost of such investigation would be far greater than the results would warrant. In fact, in a small woodworking plant such exhaustive studies would cost more than the business could possibly afford, and also as soon as the product changed would be valueless. Therefore, whenever possible, basic rates should be evolved. By

WORK DONE SHEET

Plant —— Mfg. Co. Dept. 1 Operation CO Machines 1 CO, Man Frube

Month 11 Day 2 Year 1916

TIME: Began	TIME: Finished	WORK DONE: Length of Boards Cut	WORK DONE: Total Feet	TIME: Allowed	TIME: Taken	TIME: Gain	TIME: Total Gain	REMARKS
.00	13.55	16-14-14-14-12-14-16-14-16	130	9.8	13.55	−3.75	−3.75	
13.55	22.25	14-14-14-14-14-14-14-14-14	182	13.6	8.70	+4.9	+1.15	
22.25	2.80	14-14-14-14-14-14-14	98	7.3	10.55	−3.25	−2.10	
2.80	6.40	Counting pieces			3.60A			
6.40	11.25	12, 12, 6, 12, 12, 14	68	5.1	4.85	+ .25	−1.85	
11.25	20.50	14-14-14-14-12-14-14-14-14	124	9.3	8.25	+1.05	−.80	
20.50	30.85	14-14-14-14-14-14-14-14-14	126	9.5	10.35	−.85	−1.65	
30.85	3.95	14-14	28	2.1	3.10	−1.00	−2.65	
3.95	10.95	Changing load			7.— A			
10.95	22.90	14-14-14-14-14-12-14-14-14	124	9.3	11.95	−2.65	−5.30	
22.90	2.75	14-14-14-14-14-14-14-14	112	8.4	9.85	−1.45	−6.75	
2.75	3.75	Changing instruction			1.00 A			
3.75	8.15	14-14	28	2.1	4.40	−2.30	−9.05	
8.15	11.75	Rearranging pieces			3.60 A			
11.75	20.80	14-14-14-14-14-14-14-14	112	8.4	9.05	−0.65	−9.70	
20.80	25.70	14-14-14-14-14	70	5.25	5.90	−0.65	−10.35	
25.40	2.90	Changing load			7.50 A			
2.90	12.85	14-14-14-14-14-14-14-14	112	8.4	11.95	−3.55	−13.90	

Observer R. W. Kent

FIGURE 113.—Specimen Overall Time Study of Actual Performance

this term is meant the careful exhaustive time study of an operation considering the general types of product handled and the evolution of a formula rate of such character that, knowing the physical characteristics of a unit of product a simple substitution of these simple characteristics within the formula will give the required tax. If time study is carried out with the purpose of formulating such rates, it can be accomplished for a very reasonable expenditure and is then available for all time, no matter how the product may change. Numerous illustrations of basic-time study were given in the rates outlined in the chapter on shop practice, particularly those covering the operation of the endless belt sander and the illustration of finishing by dipping the product in tanks.

Bigelow Bonus Plan

The method of wage payment to be used in a woodworking plant depends as in any other industry entirely upon local conditions. No one definite plan of wage payment will fit several plants no matter how similar their product and general equipment may be. The local labor conditions and the personnel of the labor and the management influence this very decidedly. However, an adaptation of the Emerson efficiency plan has been used by the author with considerable success in several wood-

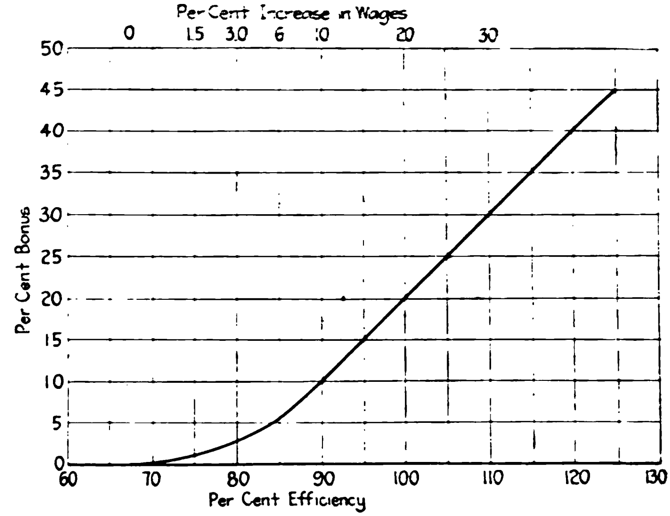


Figure 114.—Diagram of Emerson Bonus Curve

working plants. It has also been found necessary to use simple piece rates in some instances, while the Gantt bonus plan has also worked effectively in others, but the adaptation of the Emerson plan outlined below has been found particularly useful to the author, inasmuch as it not only forms an equitable basis of payment but that it also allows relative efficiencies of employees and the entire payroll to be easily ascertained in terms of simple percentages. In Figure 114 the Emerson bonus curve is shown, starting with zero at 67 per cent and increasing to 20 per cent at 100 per cent efficiency.

In Figure 115 Mr. C. E. Knoeppel's modification of this method is shown, whereby increased incentive was given the ...tive by a jump of five per cent at one hundred per cent

efficiency. The author believes that Mr. Knoeppel's modification was a valuable one, but that the point of application of the increased percentage was not as effective as if it had been given the worker sooner.

Several years' experience with the Gantt bonus plan demonstrated that the comparatively large reward for a comparatively reasonable increase in effort gained the confidence of the operatives in the method very quickly. Therefore, the author devised the curve shown in Figure 116, with this in mind. Up

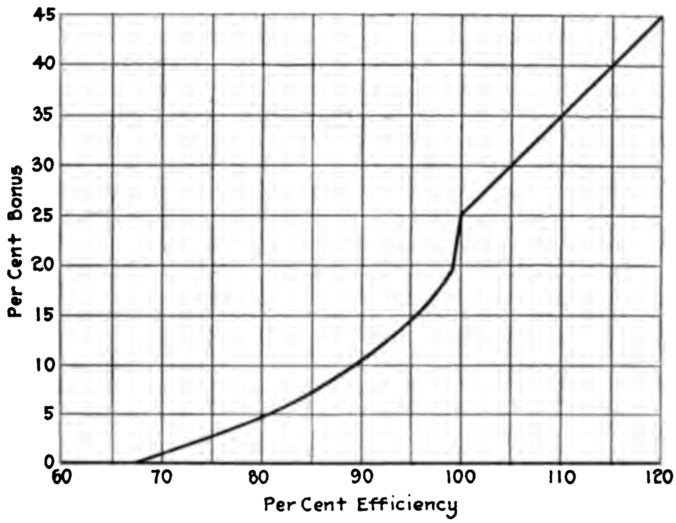


FIGURE 115.—Knoeppel's Modification of Emerson's Bonus Curve

to 70 per cent efficiency the operative is paid what is called a labor rate—that is, the fair competitive wage rate for the locality in which the installation is made. Upon attaining 70 per cent efficiency, which in the woodworking industry requires considerable effort inasmuch as the average operation is rarely more than 50 per cent efficient, the operative is paid a comparatively large increase which is called the base rate. This base rate is 10 per cent in excess of the labor rate.

Beginning with 70 per cent, a percentage of bonus is paid over and above this base rate, increasing according to Table 10 to 25 per cent at 100 per cent efficiency.

This provides for an increase in pay of 37.5 per cent to be attained for reaching an efficiency of 100 per cent which, especially within the last two or three years, has been essential to

obtain the required increase in production in the woodworking industry, inasmuch as the previous productions have been so low due to the inefficiency of equipment, operation and general control. In Figure 117 is shown the effect of the utilization of this bonus plan assuming operatives to be at 40, 50, or 60 per cent efficient.

At first examination it might be said that the increase in production was not sufficiently remunerated by the comparatively small increase in remuneration. However, it should be borne in mind that in no case does the operative work proportionately

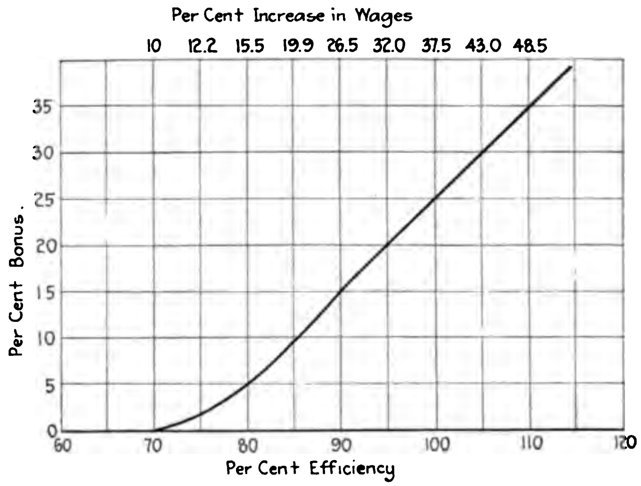


FIGURE 116.—Bigelow Bonus Curve

harder to his previous efforts as the production would indicate. This increased production is largely attained not through increased effort on the part of the operator, but through the application of his efforts properly, and by improvements in machinery, conveying devices, and in the promptness with which work is delivered to him and removed. As a matter of fact, in a large number of operations, the operator is required to exert considerable less effort. A good illustration of this will be found by referring to the chapter on shop practice in which the changes in the cutting-off operation were detailed, demonstrating that while the production increased several times, the operative was required to do far less physical labor.

TABLE 10—BONUS RATES FOR VARIOUS PER CENT EFFICIENCIES

Per Cent		
Below 70	Labor Rate—	
70	Base Rate—(Labor Rate + 10%)	
71	" +	0.3% Bonus
72	" "	0.7
73	" "	1.1
74	" "	1.5
75	" "	2.0
76	" "	2.5
77	" "	3.0
78	" "	3.6
79	" "	4.3
80	" "	5.0
81	" "	5.7
82	" "	6.4
83	" "	7.2
84	" "	8.1
85	" "	9.0
86	" "	9.9
87	" "	10.9
88	" "	12.1
89	" "	13.4
90	" "	15.0
91	" "	16.0
92	" "	17.0
93	" "	18.0
94	" "	19.0
95	" "	20.0
96	" "	21.0
97	" "	22.0
98	" "	23.0
99	" "	24.0
100	" "	25.0
101	" "	26.0
102	" "	27.0
103	" "	28.0
104	" "	29.0
105	" "	30.0
Etc.		

OVER BONUS TO BE PAID IN CONNECTION WITH PIECE WORK

Occasionally, piece rates are found in a plant, and we consider it advisable to change from this method of remuneration. The general procedure in this case is by motion and time study to readjust the piece rates, establishing them upon an equitable basis. While this requires considerable tact, it is possible by very careful study and demonstration, and by the introduction of the necessary mechanical devices, to change the piece rates with-

out noticeable friction. However, it has often been found advisable to pay an over-bonus which in connection with the piece rates, practically renders the plan one of differential piece rating, thus providing proper incentive to the operative for accumulative production which ordinary piece rates do not provide.

The following is an outline of one method used for attaining this result. This plan has been devised to provide a means of paying the workman a bonus for high production on piece work.

Working at efficiency of	Operatives are paid	Assuming operatives to be: 40% efficient, % increase in Pay	Prod.	% Saving	50% efficient, % increase in Pay	Prod.	% Saving	60% efficient, % increase in Pay	Prod.	% Saving
Below 70%	Labor rate									
At 70%	Base rate (labor rate plus 10%)	10.0	75.0	37.0	10.0	40.0	21.3	10.0	16.6	5.5
" 75%	" " 2% bonus	12.2	87.5	40.0	12.2	50.0	25.0	12.2	25.0	10.0
" 80%	" " 5% "	15.5	100.0	42.2	15.5	60.0	27.7	15.5	33.3	13.3
" 85%	" " 9% "	19.9	112.5	43.6	19.9	70.0	29.5	19.9	41.6	15.3
" 90%	" " 15% "	26.5	125.0	43.7	26.5	80.0	29.8	26.5	50.0	15.6
" 95%	" " 20% "	32.0	137.5	44.4	32.0	90.0	30.5	32.0	58.3	16.5
" 100%	" " 25% "	37.5	150.0	45.0	37.5	100.0	31.2	37.5	66.6	17.4
" 105%	" " 30% "	43.0	162.5	45.5	43.0	110.0	31.8	43.0	75.0	18.2
" 110%	" " 35% "	48.5	175.0	46.0	48.5	120.0	32.5	48.5	83.3	19.0

FIGURE 117. Results of Application of Bonus Plan

It is based on the following principles:

1 A certain standard of production before the workman receives any bonus. This standard should represent the average production of a good workman, under standardized conditions
2 Straight piece rate earnings up to and including the standard
3 For each cent that the workman earns per hour on his piece rate, above the standard, he is to receive one-half of one per cent of the value of his wages as a bonus.

Example. Assume the piece rate on a certain job is 2 cents per piece and the average earnings on this class of work or standard is 40 cents per hour. Up to and including 20 pieces per hour, the workman will receive 2 cents per piece. If the workman exerts an extra effort and turns out 30 pieces per hour, he will receive his regular piece rate, which would be, 30 × 2 cents = 60 cents per hour. In addition to his regular piece-work rate, he will receive one-half of one per cent of the total value of his earnings, for each cent that he exceeds 40 cents per hour. The bonus will be:

$60 - 40 = 20$
$20 \div 2 = 10$ per cent
60×10 per cent = 6 cents bonus per hour.

This plan is flexible and may be made to suit any case without change in the principles upon which it is based. The point at which bonus begins to be paid, may be set at any desired production and the per cent bonus paid for increased earning above this point, may be any per cent which would best meet the requirements necessary to maximum production. This, of course, is governed entirely by the conditions under which the bonus system is installed. In a place where the overhead expense is high, the management can afford to pay a high percentage bonus for increased earnings. This also holds true if the piece rates are considered low. If on the other hand, the piece rates are high and the overhead small, the concern cannot afford to pay so high a bonus and the percentage bonus for increased earnings can be made less.

This form of bonus should especially appeal to concerns who are paying their employees on a piece work basis and are interested in securing maximum production, without changing the entire wage plan to a time-bonus method. It should also appeal to the better class of workmen, as it not only gives them a chance to increase their earnings, but the plan has been so devised that the bonus per cent increases in proportion to the increase in energy required to reach high points of production. Every worker is paid according to his production ability. There is the same reward held out under this method that there is under Taylor differential system, but the principal objection has been eliminated, that of penalizing the slightly less capable worker for not reaching the maximum point of production.

Bonus Based Upon Saving in Waste

In Figure 117-A is shown a chart of a bonus plan based upon production and waste saving combined. It is figured by multiplying the number of thousand lineal feet run expressed in dollars by the Percentage Factors under Pay. For example, 45,000 lineal feet produced with 8 per cent waste would be 1 per cent × $45.00 = $0.45 bonus for the day.

General

The spirit of co-operation and contentment among the work-

men of an industry is the most valuable asset it can have, both from the manufacturing and financial standpoints as well as from the humanitarian.

To obtain such a spirit fairness and honesty in all dealings with the employees are prime factors. As stated above, the basis of fairness is knowledge, therefore all policies and procedures must be based upon carefully determined facts, and applied with tact, sympathy and kindness.

Time and motion study are of great value in furnishing such

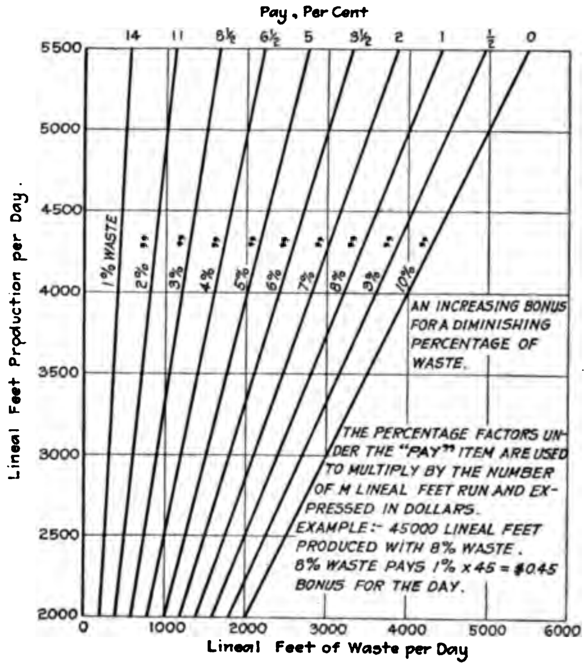


FIGURE 117-A.—Diagram of Bonus Plan Based Upon Co-operation in Reduction of Waste

facts, if properly applied and utilized, and the correct devisement of the wage-payment method, supported and tactfully enforced through the application of employment control and social service as outlined above will bring this spirit out and foster it.

Close personal contact between management and operatives is also invaluable. While the author does not believe that this personal contact alone will solve all labor problems as is being represented by some authorities to-day, it certainly is helping to do so. Coupled with adequate mechanism, such as the general labor control outlined in the previous pages, it grounds the ...olidly.

CHAPTER XI

TOOL AND FIXTURE CONTROL

IN the majority of furniture factories and many other branches of the woodworking industry in place of working from drawings, blueprints or standardized tools and fixtures, the practice is to depend for duplication of the product upon sample parts known as patterns. These patterns consist usually of the first part made, although in some instances they are reinforced with metal in order to extend their life. The usual custom is to hang these, together with jigs and other fixtures, on nails driven into posts, walls, or along the beams of the ceiling until they are again wanted. Often, in fact usually, they bear no designating marks aside occasionally from a notation made on them of the number of the unit of product into which the particular part like the pattern goes. Furthermore, as a unit of product dies out, the various patterns and fixtures are not removed, but are allowed to remain for years on the nail on which they were last hung. One of the most amusing things to be seen about many woodworking plants is the attempt to locate a missing pattern and after it is finally found to see the various maneuvers gone through to remove a pattern from its point of suspension on a ceiling beam.

The tools used in woodworking are few in comparison to the quantity used in metalworking. Very seldom is any attempt made toward their standardization or control, and they are usually found in cupboards, workmen's bench drawers, or in other more or less obscure places. The grinding of tools is left entirely to the workmen using them and practically no attention is paid toward securing the best adapted tools for each particular job. Nor, as mentioned in the section on the cutting of wood, practically no investigations have been made for securing the best types of tool steel for use in connection with wood. Like patterns, the tools are practically never symbolized.

Symbolization of Patterns, Fixtures and Tools

The first step in standardizing the fixtures and tools is to get them all together and by consultation with the shop superintendent, foremen, and in some cases with old operatives who have worked for a long time on certain operations, to eliminate all obsolete items. No attempt should be made to handle all the tools and fixtures at one time, but preferably by operations, in

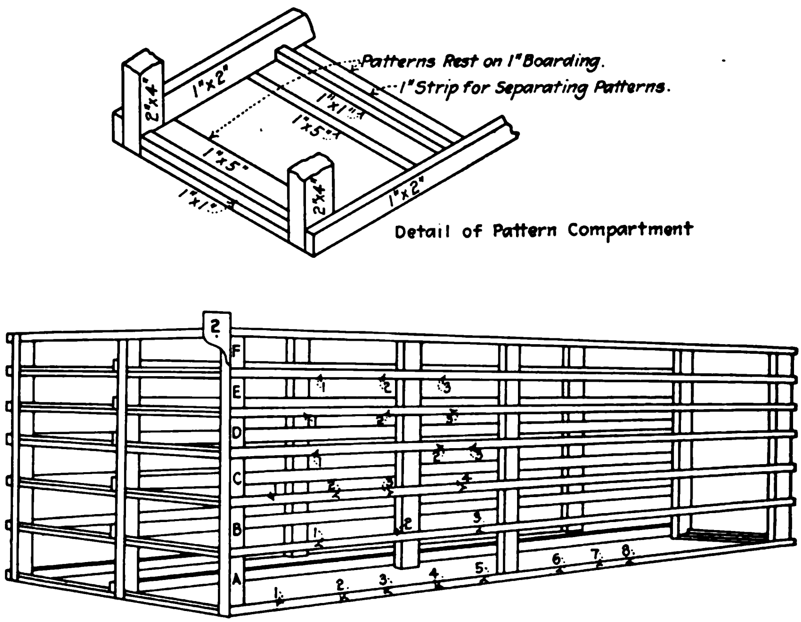


Figure 118.—Special Storage Rack for Patterns

order not to disturb too many items at one time. After the fixtures under actual use for a certain operation have been separated, these should be symbolized with the operation number followed by the part symbol for which they are used. This applies to both patterns and jigs or fixtures. For example, supposing that the shaping operation is operation Number 23 in sequence as described in the previous section on the en-routing of the plant, and that a certain shaping jig is used on square front post PFX6; the symbol for this jig will be 23-PFX6. A very good way for indicating the symbol on the patterns or jigs, which are usually made of wood, is to paint a white spot in a

prominent place on the fixture and then stencil the symbol onto this space in black. After the stenciling is dry, cover the entire white spot with a heavy coat of varnish. This will make an easily seen hard-wearing notation.

All special tools such as back knife lathe knives should be symbolized similarly, but bits can be classified according to their diameters and type, and small cutters and chuck heads either by size or by number. Numbers should be applied to steel tools by the means of stamping with steel dies when possible or when the steel is too hard, they should be etched in acid.

Storage of Patterns, Fixtures and Tools

In convenient spots about the shop, tool and pattern cribs should be erected and enclosed with wire netting and sheathing. The tools can be best handled in small steel tool racks or drawers which can be bought for this purpose, but for the storage of patterns and fixtures, special racks should be constructed similarly to that shown in Figure 118. Woodworking fixtures are so large and are so constantly changing, and the new patterns often of such an entirely new size that a very flexible method of storage must be provided. By a simple re-arranging of the cleats separating the various fixtures on the shelves of the rack, an entire rack of this type can be easily re-arranged. As shown in the figure each side of each rack should be given a designating symbol such as a numeral and the various floors or shelves given a designating letter, beginning with the lowest. Then the individual spaces on each shelf can be given a designating numeral beginning at an end. Thus 2A2 would designate rack No. 2, first shelf from the bottom second space from the end. This provides a designating nomenclature automatically locating the desired fixture and also, inasmuch as the fixtures are of various widths, allows the individual numbers to be very flexibly applied, allowing the entire space in the rack to be filled, which would be impossible if the individual numbers on the shelves were assigned to similarly sized spaces.

Fixture Records

As soon as the fixtures and tools have been properly stored and locations assigned to each, fixture data cards similar to

that shown in Figure 119 should be made out for each item, showing the location, the items of product it is used upon, and its cost. On the back of the form there should be drawn or photographically reproduced, an illustration of the article. It will

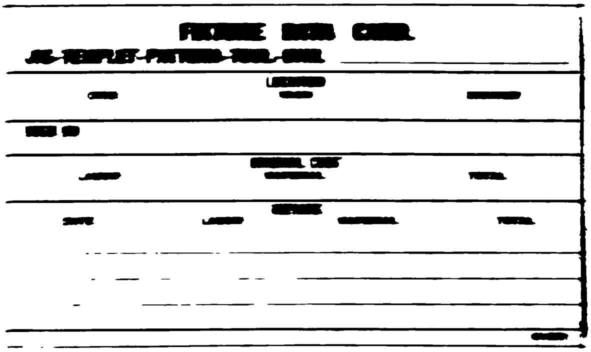


Figure 119.—Data Card for Fixtures and Tools

also be noted that space is provided on this form for collection of cost of repair data. These forms should be filed by symbol and serve as an index as to the equipment under each symbol.

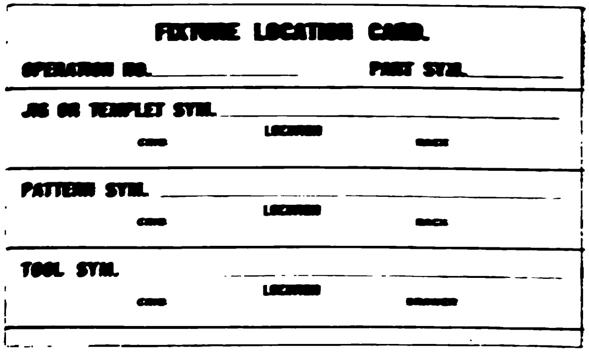


Figure 120.—Location Card for Fixtures and Tools

Next, fixture location cards such as shown in Figure 120 should be made out and filed by operation numbers and part symbols in order that having a given part on a given operation it may be easily determined what fixtures are used on this operation as well as the location of these fixtures.

Control of Pattern and Tool Crib

When the patterns and tools have all been collected, symbolized, stored, and recorded as indicated above, the tool cribs

should be locked and put in charge of the machine setters for the sections of the shop in which they are located. In the crib should be located small grinders, and when necessary a small repair bench, in order that each fixture or tool may be put into the best possible condition when it is brought back into the crib, and not allowed to remain broken or dull until next wanted. This work is done by the machine setter in charge of the crib.

The issuance of fixtures or tools from the pattern room may be put in direct charge of the machine setters, they issuing the necessary tools and fixtures against brass tool checks presented by the workmen or in larger, more completely organized fac-

<table>
<tr><th colspan="8">MACHINE SETTERS NOTICE</th></tr>
<tr><td>Clock No.</td><td>Oper. No.</td><td>Mch. No.</td><td>Date Due on Mch.</td><td>Mo.</td><td>Day</td><td>Hr.</td><td></td></tr>
<tr><td colspan="4">Name of Part</td><td colspan="3">Symbol</td><td></td></tr>
<tr><td>Oper. No.</td><td colspan="7">Description of Operation</td></tr>
<tr><td>Dr. No.</td><td colspan="7"></td></tr>
</table>

TOOLS			JIGS, FIXTURES, PATTERNS		
Number	Location	✓	Number	Location	✓

FIGURE 121.—Form for Machine Setter's Notice

tories, can be controlled by means of the form shown in Figure 121.

This form is to be made out by the Order Clerk in the Planning Department as soon as an order is written and is sent to the proper machine setter who will check in the check column all items available for use. When any fixture or tool called for on this form is not available, the machine setter will put it into condition or obtain it if possible within a short period of time. If, however, he cannot get it ready before the time designated at the top of the form on which it is due, he will return it to the Schedule Clerk in the Planning Department with a notation to that effect with reasons, on the back of the form, in order that the work will not be scheduled until the tool or fixture is available.

If all the tools or fixtures are available he will check off all items and return to the Schedule Clerk in the Planning Department who will attach it to the proper order. When an order is

scheduled the machine setter's notice is attached to the production order tag (Figure 48), which is forwarded to the foreman as previously described. When the foreman issues the order to an operative he gives the machine setter's notice (Figure 121) to the machine setter in order that he will set-up the proper tools and fixtures for the operation. However, except in very large plants the author has found that the most practical method for controlling tools and fixtures in woodworking plants is to have the machine setter simply issue them on brass checks as referred to above, making, of course, all difficult set-ups for the operative.

The economy resulting from such a control of tools and patterns cannot be tangibly estimated, but the saving in lost time to workmen waiting for tools and fixtures and in the prevention of spoiled work through improperly ground or repaired fixtures is very appreciable.

CHAPTER XII

REPAIR CONTROL

IN very few woodworking plants is there ever found a master mechanic, practically never a chief engineer. Repairs of any magnitude are sent out to job shops and the smaller repairs and installation of job work is taken care of by a millwright with an assistant or two. In other words, repairs are practically unchecked and uncontrolled and due to the necessity for holding repairs at a minimum in many shops in the past, the only re-

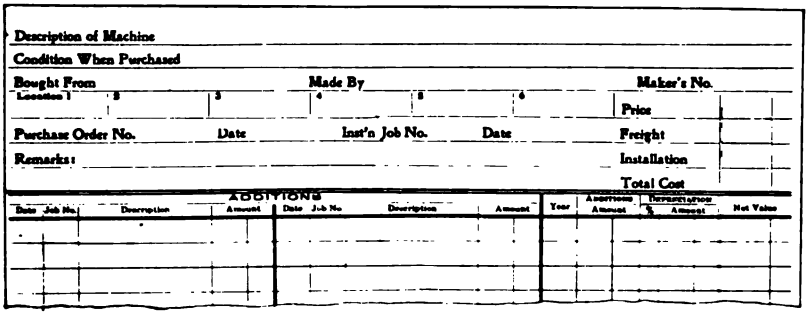
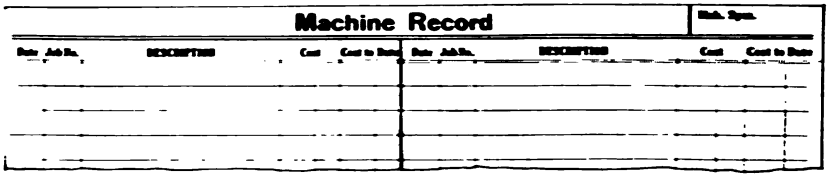


FIGURE 122.—Form for Machine Record

pairs made are to take care of actual breakdowns. In this industry, as in most others, in order to economically maintain the equipment, planned or premeditated repairs are essential. As outlined in Chapter II on organization, the millwrights should be under control of a chief engineer, or at least, a master mechanic.

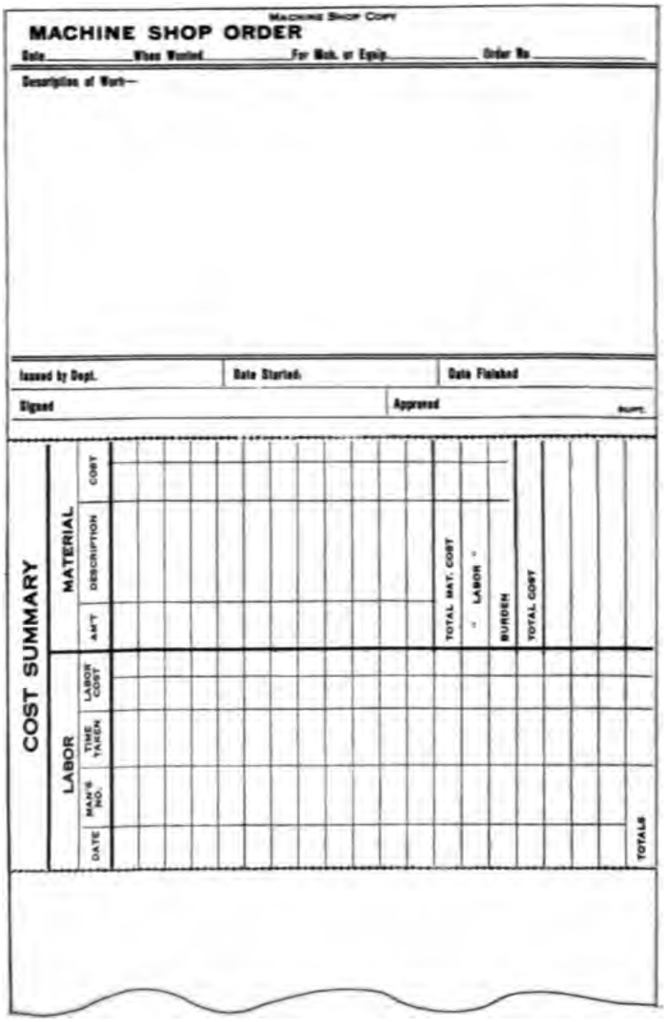
PREMEDITATED REPAIRS

As a basis for supplying the knowledge not only for premeditated repairs, but to also establish the current value of the equipment, a form similar to that shown in Figures 122 and 123 is used. The heading shown in Figure 122 is opened up to show the original cost of each item, both machines and fixtures, and



Machine Record

FIGURE 123.—Reverse of Form of Figure 122



MACHINE SHOP ORDER

Date ______ When Wanted ______ For Mch. or Equip. ______ Order No. ______

Description of Work—

Issued by Dept. | Date Started | Date Finished

Signed | Approved ______ SUPT.

COST SUMMARY

MATERIAL: COST | DESCRIPTION | AM'T

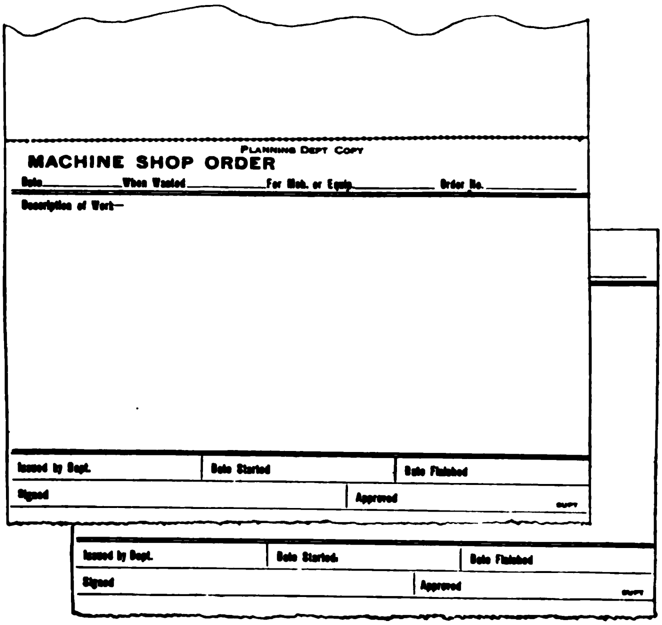
LABOR: LABOR COST | TIME TAKEN | MAN'S NO. | DATE

TOTAL MAT. COST | " LABOR " | BURDEN | TOTAL COST

TOTALS

FIGURE 124.—Form for Recording Cost of Machine Repairs

each year this is adjusted to a net value by adding any additions such as special fixtures or improvements, and deducting the depreciation. On the reverse side of this form shown in Figure 123 is recorded a description and cost of all repairs. These records of the cost of repairs should be carefully gone over each month by the master mechanic and superintendent. A careful inspection of these records of repair cost will soon reveal the fact that certain machines break down fairly regularly after certain periods of operation. If this is considered normal wear and tear,



PLANNING DEPT COPY

MACHINE SHOP ORDER

Date ______ When Wanted ______ For Mch. or Equip. ______ Order No. ______

Description of Work—

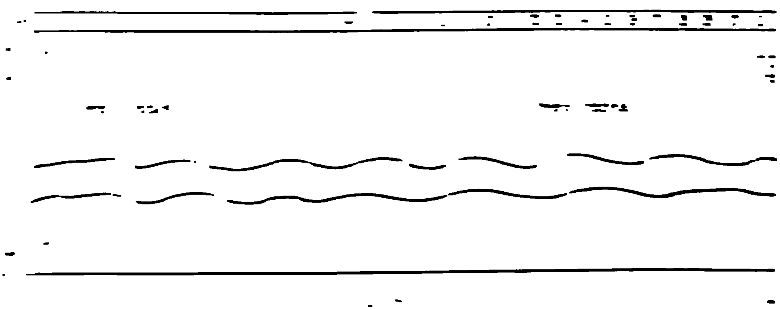
Issued by Dept.	Date Started	Date Finished
Signed	Approved	

Issued by Dept.	Date Started	Date Finished
Signed	Approved	

FIGURE 125.—Form for Machine Shop Order for Machine Repairs

periodic inspections of these machines should be instituted at such intervals that the breakdowns will be prevented, inasmuch as if during the inspection any flaw is found, it can be immediately repaired. Such inspections and repairs should be carried on during hours when the plant is not operating and thus a large amount of lost time due to breakdowns of equipment will be avoided. However, an inspection of these repair records will often reveal that certain equipment is breaking down far more than normal wear and tear warrant. In these cases the master mechanic and superintendent should take the matter up with the

[illegible]



[illegible]

[illegible]

[illegible] REPAIRS

[illegible] repairs [illegible] described above, it is necessary [illegible] the repairs. In the [illegible] managed [illegible] plants, repairs [illegible] machine when it [illegible] the plant until he finds a [illegible] the machine is broken, and often [illegible] knowledge of his [illegible] repair the machine. [illegible] Figures 124 and 125 [illegible] made out only by foremen or the superintendent [illegible] designed that by the use of two carbons [illegible] for the machine shop, another for the Planning [Dep]artment, on the back of which is a cost summary, and a du-

plicate for the foreman placing the order, is provided. Upon the receipt of the machine-shop copy, the master mechanic lays out the work for the necessary mechanics and writes material requisitions for any necessary material on material requisition (Figure 33) and schedules the work on his control board as described below. The mechanics, of course, work on time cards similar to those provided for the regular operatives in the factory, and these time cards and the material requisitions are forwarded to the Planning Department, and summarized on the cost summary on the back of their copy of the machine shop order, thus serv-

Date Issued	191
Date Due	191
Order No.	
Article	
Comp't'd	191
Foreman	

FIGURE 127.—Tag Used on Planing Board Shown in Figure 126

ing as a basis for the repair cost accumulation on the form shown in Figure 123.

PLANNING OF REPAIR WORK

A schedule board should be provided in the machine shop similar to that shown in Figure 126. This consists of a plain board across the top of which are placed the days of the month, underneath the day there being placed fifteen small hooks in vertical lines. Upon receipt of the machine-shop order, the master mechanic makes out a small tag such as that shown in Figure 127, which he places upon a hook under the day on which the job is supposed to be completed, this information being obtained from the machine-shop order (Figure 124). Inasmuch as when using premeditated repairs, as described above, there are certain jobs which he can schedule with more or less leeway, the immediate breakdowns can be provided for first, and the time of

his men assigned to [illegible] repairs. The tag shown in Figure [illegible] should be printed in [illegible]—buff and red—the red being used for all small [illegible] which must be finished [illegible] overtime if necessary. The value of this simple control board is that it not only prevents any possibility of the master mechanic losing sight of any [illegible] but that it also assists him in scheduling his repair men more effectively, which, at best, is a difficult task. With a certain number of jobs scheduled for

Figure 128.—Control Board for Machine Repairs

completion on a certain day, by estimating the time required by each and the men assigned to them, he can readily determine whether or not he has assigned sufficient work to keep his men busy and also whether his men have sufficient capacity to complete the necessary work, without overtime. In Figure 128 is shown such a control board in actual use.

This method of the control of repairs is simple but effective. In any but very large woodworking plants a more detailed method would be found cumbersome, as the repairs in the average woodworking plant are far less than those in a metal working plant of the same size.

CHAPTER XIII

WASTE CONTROL

THE subject of waste material is one regarding which there is a great deal of discussion in most woodworking plants, but toward the control of which little actual effort is made. The most common objection to making changes of almost any nature whatsoever in a woodworking plant is that "it will increase the waste," but very few woodworking executives have any tangible data as to just what their waste is, how or why it is caused, or any means of keeping it at a minimum. Like so many other subjects in this unstandardized industry it is largely a matter of personal opinion rather than of fact. In a few plants occasional tests are made but they are rarely carried out under any standardized conditions which would guarantee legitimate results, and after being made are often used as a basis for calculating waste for long periods during which conditions are changed or in connection with entirely different grades of lumber and product.

To approach this subject from the standpoint of establishing a control, it is necessary not only to determine as exactly as possible just what the percentage of waste is for different kinds of lumber, but also to provide a simple mechanism whereby it may be controlled.

WHERE WASTE IS MADE

Wastage of lumber occurs first in the lumber yard, but practically never is this form of waste considered. Usually waste is calculated on the basis of lumber actually delivered to the mill. In one large woodworking plant the author ran a test for several months, beginning with a very careful inventory of the lumber yard and following with carefully kept records of the amount of each kind and grade of lumber put into or removed from the yard. Considerable expense was incurred in order that these records might be dependable, with the result that it

was established that about 3 per cent was being lost, based on the value of the lumber in the yard, through breakage, exposure to the weather, etc., which amounted to a considerable item per year in this plant, but which never before had been figured into cost.

The greatest point of course at which waste is made is at the saws, both cut-off and rip. A little later a simple method will be shown whereby a definite record of waste at this point can be obtained.

During the various machining operations, such as boring,

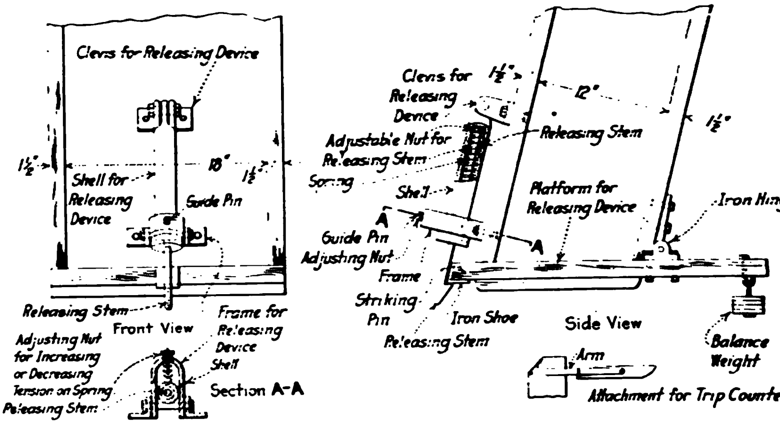


FIGURE 129.—Weighing Device for Waste

chucking, tenoning, mortising, etc., additional parts are broken or spoiled and hence constitute waste of material.

In the assembling or driving up departments a small percentage is broken, while in the storage rooms of shaped and machined parts a certain loss is experienced through deterioration, if the parts are stored any considerable length of time.

METHOD OF CONTROL

Yard. For maintaining a record of the waste caused in the yard it is only necessary to carefully maintain the perpetual inventory method as detailed in the chapter on lumber control. If this inventory is maintained with the proper accuracy, each
ı the annual physical inventory of the lumber yard is

taken a small shrinkage will be found which will represent the factor of loss at this point to be considered in estimating cost prices. This figure will be found different for various grades and kinds of lumber.

A simpler method for determining this waste in the lumber yard, and one which reflects cost rather than amount more accurately, is to add the invoices of lumber during the previous year to the annual physical inventory taken at the beginning of that year, and deducting from this sum the total amount of lumber

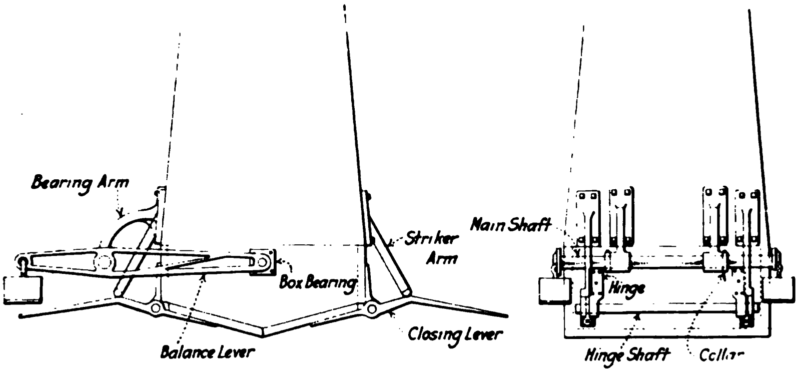


FIGURE 130.—Detail of Bottom of Hopper of Waste Weighing Device

ordered into the factory during the year. Any difference between the physical inventory at the end of the year and the above amount represents waste in the yard.

Saws. The waste from each saw should be collected by conveyors through chutes. When possible, the saws should be so arranged that all the chutes lead to one large conveyor. At the bottom of each of these chutes a weighing device similar to those shown in Figures 129 and 130 may be placed, which can be set so that it will deliver the waste to the conveyor in amounts equivalent to the weight required to open the device. By means of the tension spring this device may be so adjusted that it will deliver in lots of say 25 pounds. Each time it opens the counter registers this fact and the reading of the counter multiplied by the amount required to open the device will give the pounds of waste. From the conveyor which receives the waste from the saws, the material is carried onto a distribution table where it can be resorted for cutting up into small parts, or, if the

type of product does not warrant this, it can be carried directly to the fire room. This will later be discussed in detail. An economical form of conveyor for this purpose is shown in Figure 131. This conveyor can be built almost wholly from material available in the average woodworking plant with the exception of the belt and a few small parts. It consists of a heavy prepared canvas belt operating on wooden idler rollers with hard wood side boards. Such a conveyor can be operated very economically and with little wear. When it is necessary to carry the material up to a higher elevation than that of the conveyor itself this may be done by arranging the conveyor belt to deliver the material onto a set of chains similar to those used for conveying slabs in a saw mill. Such a device not only provides for weighing of waste but it also, if installed in the basement under the cutting room, disposes of the waste automatically, saving time for the saw operators, who in the average woodworking shop have to spend a considerable portion of their time handling the waste, and also eliminates the necessity of handling the waste from the saws to a secondary cutting point or to the fire room.

When it is desired to record the amount of waste of different kinds or grades of lumber, the weighing device must be read between the cutting of the different types. The counting device can be readily located in sight of the saw operator or foreman.

Machining and Assembling. Parts broken or discarded during the intermediate machine operations or at assembly are recorded in the cull record on the production order (Figure 48 or 49) and may be summarised upon receipt of this form in the Planning Department.

Storage. Parts becoming waste in the storerooms will be detected by the annual inventory checked against the perpetual inventory records of such stock in practically the same manner as waste is detected in the lumber yard.

Summary. From all the sources in the manner described above, the waste should be tabulated against the amount of lumber from which it resulted. For instance, when an order is complete, or rather a cutting group, which may consist of parts applied on several orders and utilized in several different units, the total amount of waste and culls should be listed and a per cent figured showing the relation of this to the lumber brought into the factory for this cutting group. When a figure has been determined from the yard inventory showing the amount of waste in the lumber yard this percentage should be added to the

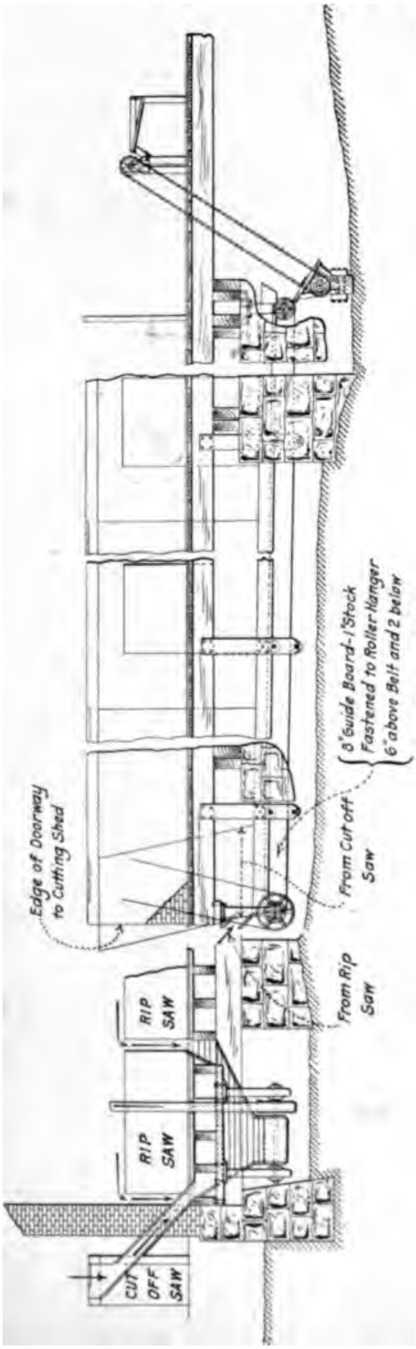


FIGURE 131.—Conveyor for Waste

other. While the above description may seem detailed the actual time required by the Planning Chief to tabulate such matter has been found in a plant cutting 2,000,000 feet a year to be about half an hour per day, and this information, if properly utilized, will be of considerable value in reducing waste in the future.

Once a week the Planning Chief should take these figures up with the Superintendent and when any cutting group shows an excessive percentage of waste, the matter should be carefully investigated and taken up with the workmen concerned. Such conferences and continual following up of waste will gradually put every member of the working force into a spirit of doing everything in his power to keep the percentage of waste down, inasmuch as he knows it is being carefully controlled and watched.

A simple method of determining waste and which should in the author's opinion be carried on as a check upon the more detailed method outlined above, is as follows: Maintain a careful record of all the lumber brought in on each cutting group and figure the net lumber utilization of the finished number of parts put into stock room or utilized in the product directly from such cutting groups, and the difference will represent the gross per cent of waste. While this will serve as a valuable check over the collection of waste information by separate operations as detailed above, it cannot be used as can the detailed method for controlling the waste, inasmuch as it makes little impression to go to a workman and say that the waste increased 1¼ per cent for the entire plant last month while if you can tell him that on cutting group number so and so, "that last large order for rockers showed a waste of half again as much as the previous order," you will have an opportunity to get some actual information as to the reason. He may recall that the lumber was badly checked, in which case you know that you must investigate both your kiln drying and covering of piles in the lumber yard. In other words, to be effective, your control must cover the subject in small groups, and by specific operations.

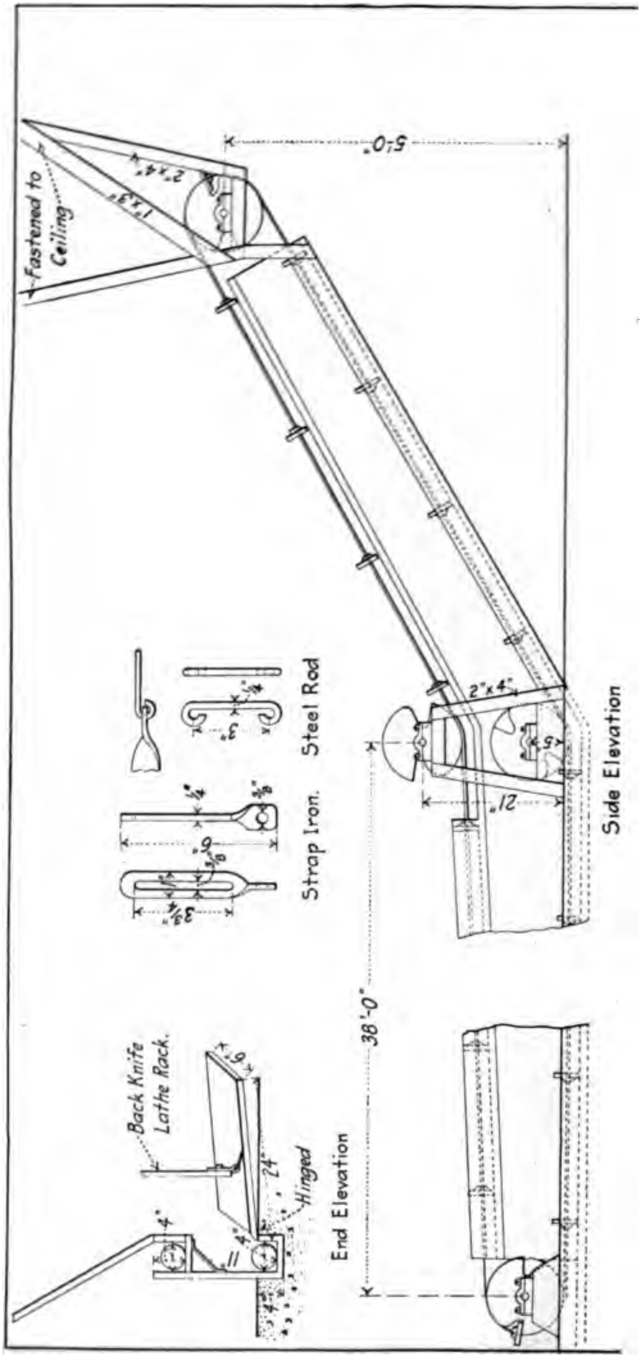
Disposal of Waste

Handling. The disposal or utilization of waste is a separate problem from that of keeping waste at a minimum. Having the

waste, what is the best disposal of it? In the first place, we must consider handling it physically. In the description of the control, we discussed the handling of the waste by means of a conveyor from the saws. There are two other points where mechanical devices will be of assistance in handling waste,—shaping, and turning. Suction pipes connected with a blower system have not been found satisfactory for these operations inasmuch as it is practically impossible to design an exhaust head which will receive the shavings from all the various angles at which the knives throw them, and also because such heads get in the way of the operative on certain types of product. A conveyor, however, can be easily designed which operates behind a battery of shapers delivering the shavings directly into an exhaust head that will pick them up easily if they are forced into its entrance by the conveyor.

At the turning operations, especially using back knives, another tremendous amount of shavings are made, which are impossible of collection by an exhaust head although several varieties of flexible traveling heads have been designed for this purpose. The conveyor shown in Figure 132 consists simply of an endless cable with lugs running in a trough which easily conveys the light bulky shavings to an exhaust head. The conveyor mentioned above for use with shapers is of a similar principle.

Utilization. Where a more or less constant sized product is being manufactured in a woodworking plant, which can be to a large extent cut from dimensioned stock or sorted sizes of lumber, the waste will be so small that unquestionably the best utilization will be to run it through a hog and blow it direct to the boilers. In the furniture industry, however, where such a variable-sized product is made, some utilization of the larger pieces of waste must be made. After considerable study by the author, he believes that the best utilization for this material is to obtain some small by-product such as pegs or handles and run all the waste through gang saws and then through automatic machines for making this by-product. This reduces the labor cost of such utilization to a minimum. Current practice, however, in the furniture industry is to resaw such material into smaller parts used in the product. This requires an excessive amount of sorting and handling to separate the green from dry lumber and the various kinds of lumber, as usually the different items of product can only be made of some one particular kind of wood. It also requires a careful detailed method to control such mis-


Fastened to Ceiling
2"x4"
1"x3"
5'-0"
Strap Iron.
Steel Rod
2"x4"
12"
Side Elevation
Back Knife Lathe Rack.
Hinged
24"
End Elevation
38'-0"

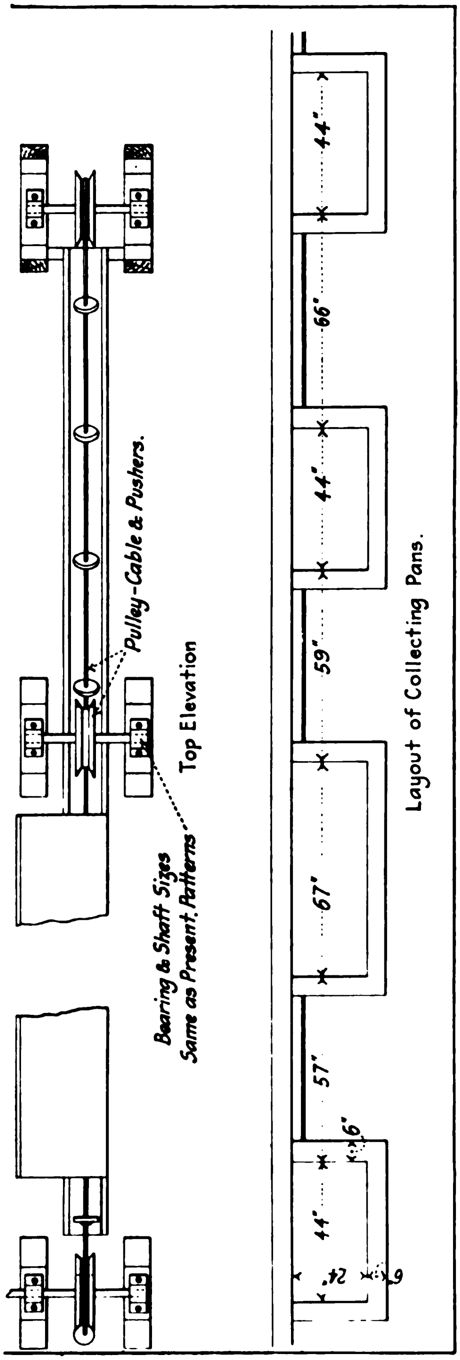


FIGURE 132.—Conveyor for Waste from Shapers.

cellaneous cutting. In a previous section on standardization of the product, it was pointed out that stretcher stock could be much more cheaply cut from new lumber than it could be from waste. It is a short-sided policy to expend more in labor than the salvage of the material warrants.

General

The waste problem then resolves itself into standardization of the following details.

- *a* Handle the waste automatically by mechanical means whenever possible
- *b* Collect data as to the percentage of waste in sufficiently small units, preferably cutting groups, to be able to present definite cases to the operatives in order to obtain their co-operation in reducing waste
- *c* In utilizing the waste in the manufacture of either direct product or by-product, be careful not to expend more labor than the salvage value of the material warrants.

In standardizing these details it should be assured that the information is predicated upon fact and not opinion. By the use of waste figures which the workmen have found by experience are true, little difficulty will be encountered in obtaining their co-operation in bettering the utilization of the lumber.

CHAPTER XIV

POWER PLANT

BECAUSE of the cheapness of a large part of the fuel—waste or offal—in a woodworking plant, in the majority of such plants the question of the cost of power is given but scant attention. In many large saw and planing mills this is more or less excusable, inasmuch as after supplying all the power and heat necessary for the use of the plant, electrical current for the local village and all other possible uses, a large quantity of heat has to be wasted by burning the surplus offal in a destructor. In the average furniture factory, however, the waste seldom supplies all the heat and power required, and the balance must be supplied by the use of coal. Under such conditions, the power problem requires careful analysis and constructive development. The proper application of power economics to such problems is difficult due to the variation in fuel, but when carefully utilized, are capable of realizing appreciable reductions in power cost.

Principles to be Considered in Using Wood as a Fuel

The fundamental principles to be controlled in burning wood are as follows:

1 Proper methods of mechanical or hand firing and draft control must be provided in order that the varying size of the product (sawdust, chips, and scrap) may be all economically handled without
   - *a* Developing losses through temporary lowering of temperature of gases through excessive draft
   - *b* Losses through distillation of gases below ignition temperature.

2 When part coal is used as fuel, furnace must economically develop heat from both wood and coal.

1 (*a*) *Prevention of Draft Losses.* When burning wood, or wood and coal mixtures, a thick fire must be maintained often from three to three and one-half feet to prevent draft blow-

holes. This often requires that the grate surface be lowered. Sawdust and hogged fuels are usually automatically stoked from overhead, while coal and scrap are hand-fired or pushed in by a screw-conveyor horizontally.

1(*b*) *Maintenance of Ignition Temperature.* The moisture content greatly influences this factor. When wet fuel is used, contact with large areas of hot brickwork is very essential to maintain ignition temperatures and prevent fuel losses. Long combustion chambers and baffles provide these areas.

2 *Provisions for Varying Fuel.* When it is considered that average coal contains 68 per cent carbon and 12 per cent oxygen, while wood contains 50 per cent carbon and 40 per cent oxygen, it can readily be seen that very different draft conditions and very variable amounts of air for the maintenance of complete combustion are essential. While wood requires less oxygen or air as draft for the initial stages of combustion, the larger quantity of more volatile gases distilled from wood after the initial stages, demands a far greater combustion space than do those from coal, therefore furnaces designed for the cumbustion of wood offal must be capable of reducing the draft intake of air but be provided with large combustion spaces. In checking the utilization of wood as a fuel 2¼ pounds of dry wood can be considered equivalent to one pound of good grade bituminous coal. Considering this fact together with the additional one that for similar grate areas it is possible to develop practically the same boiler horsepower with wood as with coal, it is very evident that provision must be made for a far greater bulk of material as well as practically continuous feeding.

In the average furniture factory sawdust from saws and sanding department and chips from shapers, boring machines, mortisers, tenons, etc., are collected by suction and blown directly into the boilers. Considerable care must be exercised in designing the boiler intakes and the dust arrester or cyclone in order that as much of the air current is broken up in the dust arrester as possible and that the sawdust and chips fall by gravity into the furnace. Unless the pressure of air blowing the chips and sawdust to the boilers is thus arrested, cold areas will be caused beneath the intakes in the fire and flue losses will develop through the introduction of the cold air into the combustion area.

The best general practice in firing offal and coal combined as it is necessary in most furniture plants appears to the author

as follows: Sawdust and chips should be fed continuously through overhead intakes. The fire should be kindled with a combination of wood waste and coal. Wood waste, usually delivered to the floor of the boiler house by a conveyor should be stoked by hand if it is in the form of cuttings and blocks, or by a screw conveyor if it has been hogged. Occasionally hogged material is blown in, but the shredded nature of such material makes it difficult to so feed without introducing excessive air into

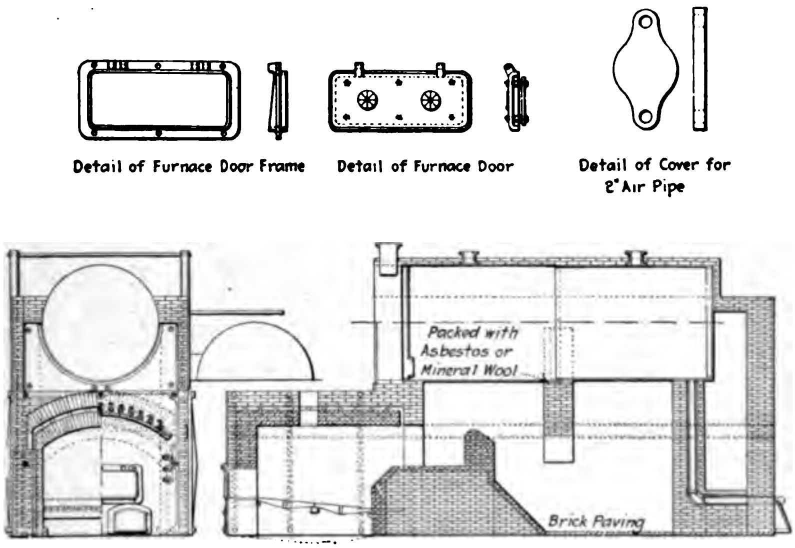


FIGURE 133.—Furnace and Boiler for Burning Wood Waste

the combustion chamber. When the offal supply becomes diminished coal should be stoked until the supply of wood waste has again accumulated.

The design of a furnace and boiler for burning such a variety of materials, if it is to be operated at a high efficiency, must receive particular attention and be capable of adjustment as the fuels vary. D. M. Myers, in his excellent book Preventing Losses in Factory Power Plants, describes an excellent design for this purpose as shown in Figure 133. In this design separate storage bins were provided for the sawdust and for the bulkier and miscellaneous materials. It was further arranged to feed the sawdust separately through the top feed hole up to the full capacity of the furnace until this supply was depleted. Then this feed hole is sealed, and the slabs, end-cuts, and other

forms of wood charged by means of a pusher from a steel floor level with the grates. The vertical sliding door being capable of quick opening and closing prevents excessive entrance of air during the feeding operation. When coal is fired this is done through the same sliding door and the fuel is either spread or fired by the alternate or coking method.

As the grates are of a proper air spacing for fine sawdust, the correct regulation of the air supply for the other fuels used is accomplished by adjusting the admission of the required amount of air by means of the levers connecting the air valves on the front of the furnace. This air becomes preheated by the wall and combustion arch of the furnace, and is admitted to the fire at points surrounding the throat, thus producing somewhat the effect of an Argand burner. The large combustion space, baffle walls, and explosion doors complete the principal features of the equipment.

Although the air requirements and heat values of sawdust and coal differ greatly, either fuel will develop about the same number of heat units per square foot of grate surface per hour. It is largely this fact that makes possible the utilization of such different fuels on the same grate and in the same furnace. The above furnace was reported by the owner to be consuming the calculated amount of wood waste and when this material is lacking the furnace burns soft coal without smoke. The high combustion is indicated by 12 per cent CO_2 as average in a month's run.

Standardization

The actual manipulation of the boiler plant should be carefully studied and standardized. Local conditions and the peculiarities of each individual installation make each plant a special study by itself and the technicality of the questions involved render it imperative that a professional engineer be engaged to develop standardization of operating practice as well as to correct any faults of design if a high operating efficiency is to be maintained. Draft gauges, D'Orsat apparatus, steam flow meters, etc., should be installed and records maintained showing the operating conditions from day to day. Illustrating the possibility of standardization of boiler control is the following standard instruction for firing boilers.

BONUS RATE FOR WORK OF FIREMEN

Rate Symbol

None necessary. Bonus entirely dependent on CO_2 readings.

Work Performed Under this Rate

Firing furnaces, properly cleaning grates and handling coal from hopper, including weighing. When the coal to be used must be brought from the bins or piles by means of wheelbarrows this work will be done by the coal handler and not by the firemen.

Data

2—300 horsepower Heine Safety Boilers
1—250 horsepower Heine Safety Boiler
3—Hay's Draft Indicators
1—Spencer Automatic Damper Regulator
2—Hay's Draft and CO_2 Recorders
1—Hay's Improved D'Orsat Gas Analyzer
Note:—All three of the above boilers are equipped with Files Hand Stokers.

Description of Condition Previous to Installation of Bonus

The theory upon which the Files hand stoker is based is to shovel coal on the first section of the grate and coke it there, then work it back by means of the hand stoker to the other two sections and in this manner the coal will be completely burned by the time it reaches the dump plate at the rear, and there will be no live fire against the bridge wall and therefore it will not clinker so badly against the bridge walls and the side walls and in addition will provide a clean fire at all times, practically free from ashes, thus materially aiding in obtaining good draft.

In practice it is very difficult to get the firemen to use these hand stokers properly. They much prefer to shovel on a lot of coal at once and then sit down and rest for fifteen or twenty minutes, then shovel on another large quantity. In order to keep up steam with this method of firing it is necessary to distribute the fresh coal evenly all over the grate surface. This keeps a live fire against the bridge wall and on the dump plate at all times, thus forming more clinkers and burning out the grates more rapidly.

The chief objection, however, to the above method of firing is that the fires become full of holes if left for such a length of

time without attention, thus allowing a great excess of air to flow through the grates. This excess air prevents perfect combustion and cools the flue gases, so that there is a large preventable loss in the flue gases.

Recommendation for Standardization of Condition and Cost

To determine the preventable loss in flue gases the CO_2 re-

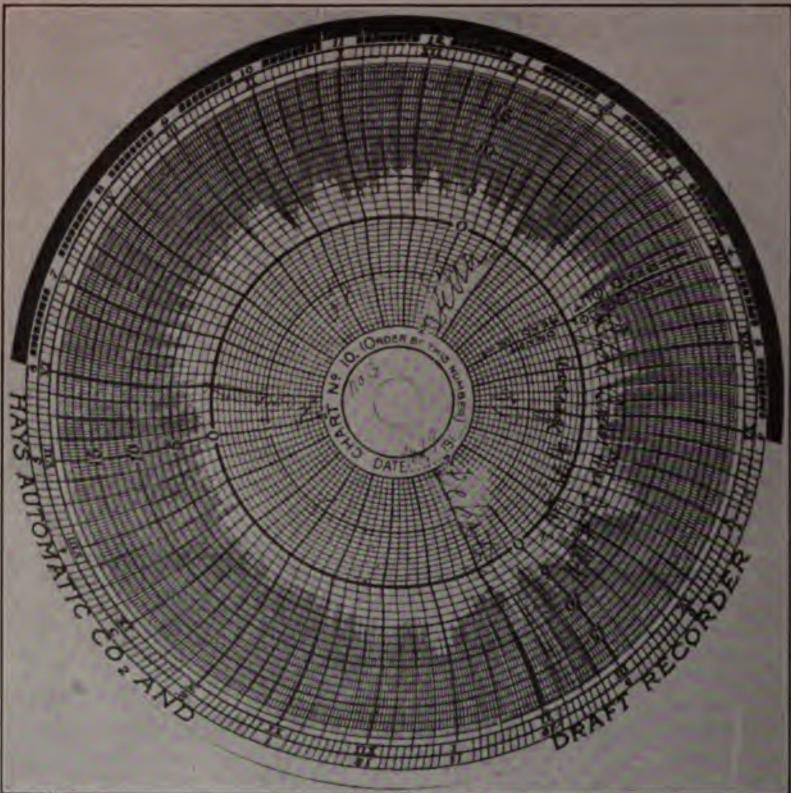


FIGURE 134.—Chart From CO_2 Recorder When First Installed

corders and draft gauges were installed. It was found that the firemen were getting less than 6 per cent CO_2 at the time the recorders were put in (Figure 134). The firemen have been taught to fire so that at the present they are getting about 11 per cent or 12 per cent as an average CO_2 reading as shown by Figure 135.

To maintain a good CO_2 reading it is necessary to fire all coal

on the first section of the stoker and, when it has become well coked, work it back by means of the hand stoker and the fire hoe. Also the furnaces must be fired often and only a small quantity of coal shoveled on each time. This will avoid clinkers to a large extent, keep cleaner fires and avoid burning out the grates so fast.

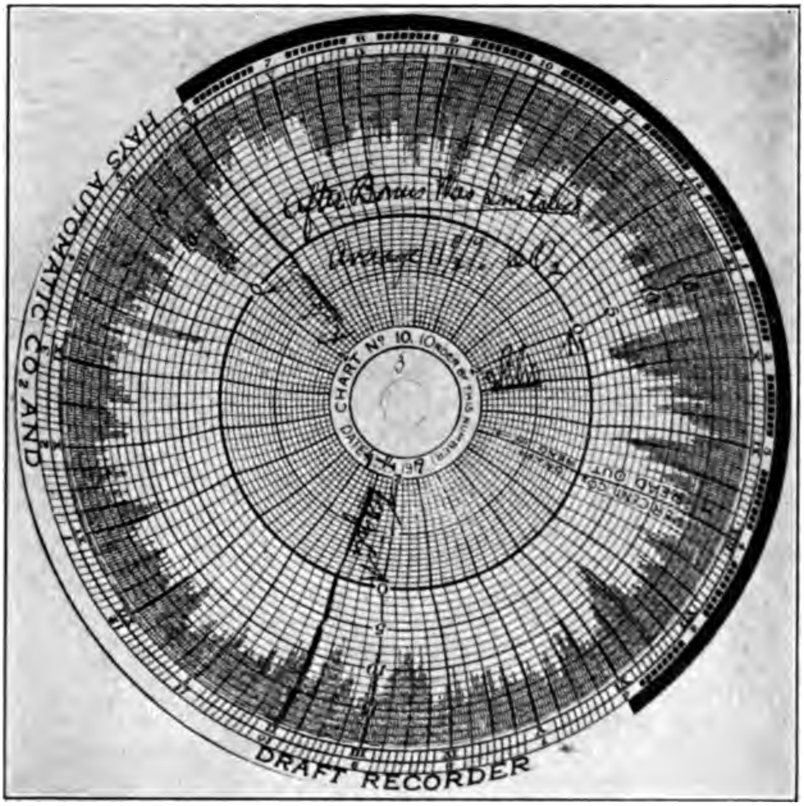


FIGURE 135.—Chart From CO_2 Recorder After Firemen Had Been Instructed in Economical Firing

Saving and Bonus Rate

Table 11 shows the bonus paid for each per cent CO_2 maintained and also shows the resultant saving to the company over previous costs for such performance.

The charts are integrated by means of an Amsler polar planimeter. The average reading for the seven days of the week for each of the men is added and the average obtained for the

TABLE 11—AMOUNT OF BONUS PAID FIREMEN AND SAVING OF COAL FOR EACH STEP ATTAINED IN INCREASING THE PER CENT CO_2

Average per cent CO_2	Corresponding Area of Chart Square inch	Per Cent of Weekly Wage as Bonus	Increase in Wages Each Man on Rate of $25	Total per week all 3 Shifts	Preventable Loss in Coal: Per Cent Loss *	Preventable Loss in Coal: Dollars per Shift Weekly	Preventable Loss in Coal: Dollars per Week all Shifts	Difference between Loss at 6 per cent CO_2 and Loss at each other per cent up to 15 per cent	Saving per Week	Per Cent Saving
6.0	6.39	Below	....	....	17.0	65.35	190.00	....	....	....
7.0	6.40	6.82	....	....	13.0	50.00	150.00	46.00	46.00	4.0
8.0	6.83	7.24	0.50	1.50	9.7	37.33	112.00	84.00	82.50	7.1
9.0	7.25	7.69	1.00	3.00	7.6	29.27	87.80	108.20	105.20	9.1
10.0	7.70	8.23	2.00	6.00	5.7	21.93	65.80	130.20	124.20	10.7
11.0	8.24	8.69	3.50	10.50	3.1	15.80	47.40	148.60	138.10	11.9
12.0	8.70	9.22	5.00	15.00	2.8	10.80	32.40	163.00	148.60	12.8
13.0	9.23	9.74	6.00	16.00	1.8	6.73	20.20	175.80	157.80	13.5
14.0 and up	9.75	Up	7.00	21.00	0.8	3.08	9.25	188.75	165.75	14.2

week and by referring to the bonus curve shown above, the corresponding bonus is obtained.

It will be the duty of the Chief Engineer to remove finished charts from CO_2 recorders and place new charts in recorders each day. He shall also change the primary filters at the boilers and the filters at the recorders at least every other day and blow out the pipes into the boiler and to the recorders by means of compressed air.

Once each day the Chief Engineer will make check tests with the Hay's improved D'Orsat gas analyzer, covering at least three readings on each recorder and he shall write on each chart both the reading of the recorder and the corresponding reading of the analyzer for each reading made.

The above method is one which can be installed with comparative ease in any woodworking plant, if the equipment is properly designed and the operation standardized, and the firemen given a means of checking their own efficiency. The recording apparatus used above was found by actual practice to not only definitely indicate the resulting efficiency of operation, but

* These percentages of preventable losses are taken from tables shown in J. W. Hay's book How to Build up Furnace Efficiency. To obtain the loss in dollars these percentages were multiplied into the average coal consumption and by $8.70, which is the cost per ton. The average coal consumption over a period of three months was found to be 132.7 tons per week, therefore the average total cost per week is approximately $1155.00.

At the time the bonus was started an average of considerably below 6 per cent CO_2 was being made, so above figures are very conservative.

it also provided a constant visual index for the firemen as to their operating efficiency and was actually used by them to increase their own effectuality. An average of 12 per cent CO_2 has now been maintained in this plant for several months with an increase of 20 per cent in the earnings of the firemen with a resultant saving of nearly 13 per cent of the coal bill. Wherever coal is used as part or entire fuel in a woodworking plant a similar form of boiler standardization will be found a good investment.

Engine Plant

The engine plant is also worthy of careful attention. In these days of high fuel cost the use of the steam must be as economical as possible. In the majority of old woodworking plants simple non-condensing engines are encountered. But in many newer plants the cost of making the power has been so excessive that the plants have been electrified and hydroelectric current purchased. Where there is a considerable quantity of waste fuel available, however, it is questionable whether such electrification is economical in a woodworking plant. For new installations, turbo-generators should be considered. These allow the added effectuality of electrical drive to be realized, coupled with economical production of the power locally. For increasing the capacity of older power plants and for additional auxiliaries, low-pressure turbines may be employed and operated on the exhaust from the older engine plant. Steam turbines are highly efficient over a considerable range of load, may be run condensing or non-condensing as desired according to local heating requirements, and may be designed for the use of both high and low-pressure steam. This makes them extremely adaptable under very variable conditions and together with the fact that they require only a small part of the attention which an ordinary engine requires and that the space occupied in the power house is usually less than half that required by an engine of the same capacity, are strong factors in favor of their use.

However, no matter what the type of engine used, standardization of operation and control, by means of bi-daily indication, or other method, should be adopted, and the engineers remunerated in proportion to the maintenance of such standards.

In conclusion it should be remembered that cost of power in all plants, both woodworking and others, requires to-day careful

analysis. Fuel is high, and may be even higher in the near future. The cost of power per unit of product in some plants may be a very small figure, but the total amount paid annually for fuel even in the smaller of the woodworking plants is not an insignificant item. This figure can be reduced very appreciably by intelligent analysis and control of the local power problems, coupled with the provision of an incentive to the engineers and firemen for the maintenance of the standard practice, once it has been developed.

CHAPTER XV

COST ACCOUNTING

COST accounting for the woodworking industry can very easily be allowed to become so detailed that the cost of maintenance of the system becomes greater than its utility warrants. Inasmuch as the material, being largely wood, is a more or less variable quantity, and of necessity introduces the use of certain factors and prorations, in addition to the usual estimations encountered in cost finding, any method of accounting which endeavors to subdivide the various items too closely is of doubtful utility. This is chiefly owing to the fact that since many basic figures are themselves the result of estimate and proration, any method which carries its calculations and deductions to extremes is a fallacy. The general plan of cost accounting for a woodworking plant as recommended by the author is illustrated by Figure 136, which is the basic plan from which uniform plans of cost accounting have been devised by the organization with which the author is connected for three associations of woodworking manufacturers, namely chairs, wire-bound boxes, and wooden-ware, as well as numerous plans for individual manufacturers of wood products such as tables, lumber, veneer, case-goods, filing devices, etc.

The term cost, as applied to manufactured products, is subject to various interpretations that differ materially one from another. For example, to some individuals the term cost means nothing further than the value of material and labor consumed; to others it also includes the expense incurred in running the plant; to others again, it represents not only the total cost of material, labor and expense of running the plant, but also the expense of administration and selling; while to still others, it embraces all possible outlays, even those incurred for interest.

GENERAL PLAN

In applying costs for the woodworking industry, the plan out-

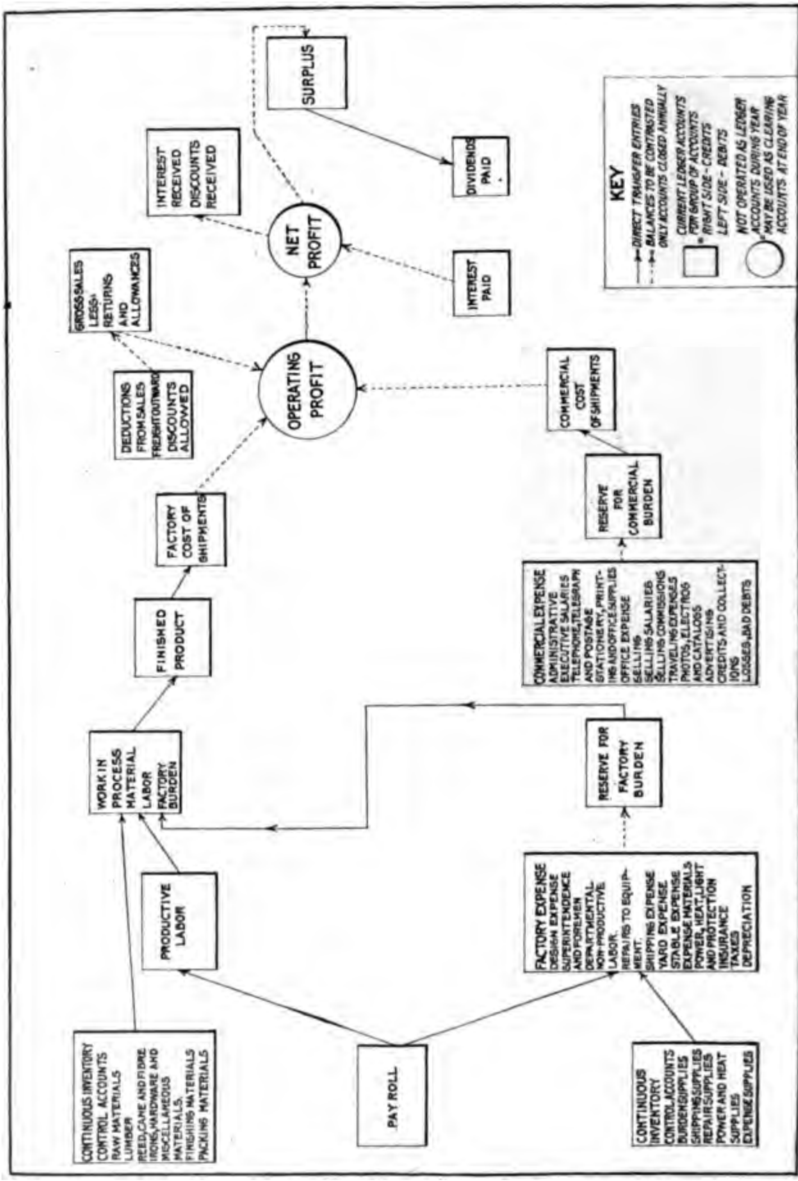


FIGURE 136.—General Cost Accounting Plan for a Woodworking Factory

lined in this chapter is covered by the following formula, which includes and illustrates the successive stages of cost accumulation from gross sales to final net profit.

Gross Sales, less returns and allowances		G. S.
Less:		
Freight—Outward	F	
Commissions	C	
Discounts	D	
Total Deductions from Sales		T. D.
Net Sales		N. S.
Less Factory Cost of Shipments:		
Materials Consumed	M	
Direct Labor Employed	L	
Factory Burden, or Indirect Cost	B	
Total Factory Cost of Shipments		F. C.
Gross Manufacturing Profit		G. P.
Less Commercial Cost of Shipments:		
Administrative Expense	A	
Selling Expense	S	
Total Commercial Cost of Shipments		C. C.
Operating Profit		O. P.
Other Income:		
Interest and Discounts Received		I. R.
Total		S. T.
Other Charges:		
Interest Paid		I. P.
Net Profit		N. P.

Some cost accountants will, of course, differ regarding this method of handling interest, but in connection with the woodworking industry our experience has demonstrated that this method is the more feasible. The plan outlined above embraces the establishment of continuous inventory control accounts for raw materials and burden supplies. Records of raw materials and supplies consumed each month are obtained and the value transferred to an account which represents the value of work in process. The productive labor employed each month is analyzed, and also transferred to the account representing the value of work in process.

Various accounts are maintained representing the factory burden or indirect cost of operation. The relation of the cost of factory burden and the cost of productive labor is determined and ratios of burden expense developed. Each month, in proportion to the productive labor employed, a charge is made to the

account representing value of work in process for the proportionate share of burden applicable to work in process. The amounts so applied are credited to a reserve account, the object of which is to indicate as to how closely the charges to work in process for factory burden compared with the actual cost of factory burden as shown by the aggregate of balances in the various factory expense accounts.

Records of product finished are obtained which are calculated at cost values, the aggregate being credited to the account representing the value of work in process and charged to an account representing the value of finished product. At this particular point in the plan of accounting, the plan must be varied according to the individual needs of a manufacturer. In some cases, instead of one account representing the value of work in process, several accounts will be necessary representing the value of work in process at successive stages of manufacture, such as stock parts or product assembled in the white.

Having accumulated the cost of all goods entering into the finished product account, the cost of all shipments is calculated and the aggregate is credited to the account representing the value of finished product and charged to an account representing the factory cost of shipment.

Various accounts are maintained representing the details of administrative and selling expenses and in order to be assured that the ratios of administrative and selling expenses to the total factory cost are correctly employed in cost calculations, there is provided an account representing the commercial cost of shipments to which is charged an amount representing the estimated value of administrative and selling expenses based upon the factory cost of goods shipped. The amounts so charged to the commercial cost of shipments are credited to a reserve for commercial burden. The balances in the latter account represent the aggregate of amounts applied to the commercial cost of shipments for commercial burden, and should be in substantial agreement with the accounts representing the details of administrative and selling expenses.

Separate accounts are maintained representing the cost of freight outward, commission, and discounts allowed, which are considered as deductions from gross sales. All returns and allowances are charged against gross sales.

In order to determine the operating profit, therefore, in the manner indicated in the formula outlined in the foregoing, the

amount of sales after the deductions have been made will be contrasted with the factory cost of shipments, plus the commercial cost of shipments, with the object of showing the operating profit.

Interest transactions will be considered after the determination of the operating profit and will be considered as direct additions thereto, or deductions therefrom, in order to arrive at the net profit. The transactions briefly described in the foregoing are to be recorded by months, with the very important object of obtaining a statement of monthly earnings.

ESTABLISHING BURDEN RATES

One of the first steps in establishing costs is to work out the ratio of burden to the direct labor charges for the various departments of the business. This is to provide the mechanism for making a charge each month to the account representing work in process, to cover the burden applicable to the cost of the product, in proportion to the amount of direct labor incurred during the month. It is preferable to make these charges at percentage rates according to the individual departments; that is, the ratio which the expense in a department bears to productive labor in that department is determined, and for all productive labor charged to work in process there is a further charge made to that account, based upon the departmental percentage rate, to cover the burden applicable to the cost of the product. Thes amounts are credited to the reserve for factory burden acount, which represents at all times the accumulation of amounts applied to the costs to cover the burden charges. The principal advantages of the use of departmental expense rates in the calculation of burden charges are (1) Closer values may be obtained for determining the selling price of partly finished product. (2) Closer values may be obtained for use in pricing the inventory, which would, of necessity, be found in all stages of process.

It is unquestionably true that this refinement requires additional clerical labor, which some manufacturers might not wish to supply. It is recommended, however, that at least three general factory burden rates, as follows, be provided:

1 A rate to cover the operations to and including the product in the white
2 A separate rate to cover the operations of finishing

3 A separate rate to cover the operations of upholstering.

These rates are essential first, because some manufacturers sell the product in the white; second, because other manufacturers, while not selling the product in the white, nevertheless have stocks of assembled goods in the white, and third, because nearly all have stocks of parts, the cost of which should not be affected by one general ratio of overhead expense which would include finishing and upholstering costs.

The aggregate of the general accounts representing the burden of indirect costs of manufacture will be in substantial agreement with the aggregate amounts of burden applied to the cost of production, as shown by the balance in the reserve account, if the production be upon a normal basis, and the ratios of burden cost correctly compiled. Should the aggregate of the balances in the expense accounts be greater than the aggregate of burden applied, it would indicate that an increase should be made in the ratios used in applying the burden, but, on the other hand, should the aggregate of the balances in the expense accounts be less than the aggregate of burden applied, a decrease should be made in the expense rates. Should such variations occur as the result of abnormal operating conditions it is recommended that no radical changes in the expenes rates be made, but rather that the variations should be considered as a separate charge to the operating profits of the year. It is not advisable, for comparative purposes, to absorb in individual costs extraordinary expenses due to abnormal conditions.

The method of working up the percentages of burden in relation to direct labor varies with local conditions and at individual plants. Certain items, such as supervision, are distributed over the various departments in ratio to the direct labor itself, while others, such as heat and light, are apportioned according to floor area. The local conditions must be carefully examined to determine the proper basis for each case.

Then the records of the previous year are examined, analyzed and a burden statement developed, similar to that shown in Figure 137. Before the actual figures are introduced into the statement, however, they should be gone over with the General Manager and revised to exclude any abnormalities peculiar to the previous period, and to provide for any unusual items which are expected to occur in the subsequent period, which the statement is to cover. Such a statement should be prepared an-
semi-annually or even oftener. It provides the basis for

setting up the reserve for burden referred to above. A completed burden statement is shown in Figure 138.

Absorption of Factory Costs into Financial Accounting

A very essential feature of any cost plan is to so absorb and check the actual accumulated cost figures by financial accounting, that the total of all individual cost figures will be reflected and

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BURDEN STATEMENT AND DISTRIBUTION

Account	Book Amount Year Ending (Date)	Basis of Distribution	Estimate for Year Ending (Date)	Dept. 1	Dept. 2	Dept. 3
Superintendence............	$ 00.00	A and S	$ 00.00	$ 00.00	$ 00.00	$ 00.00
Non-Productive Labor......	00.00	S	00.00	00.00	00.00	00.00
Repairs to Plant...........	00.00	B	00.00	00.00	00.00	00.00
Repairs to Equipment......	00.00	S	00.00	00.00	00.00	00.00
Repairs to Tables..........	00.00	A	00.00	00.00	00.00	00.00
Shipping Expense.........	00.00	A	00.00	00.00	00.00	00.00
Drayage....	00.00	A	00.00	00.00	00.00	00.00
Yard Expense..............	00.00	A	00.00	00.00	00.00	00.00
Expense Materials..........	00.00	S	00.00	00.00	00.00	00.00
Power.....................	00.00	D	00.00	00.00	00.00	00.00
Heat, Light, Protection.....	00.00	B	00.00	00.00	00.00	00.00
Insurance—Fire........	00.00	C	00.00	00.00	00.00	00.00
Insurance—Liability........	00.00	A	00.00	00.00	00.00	00.00
Taxes.....................	00.00	C	00.00	00.00	00.00	00.00
Depreciation..	00.00	C	00.00	00.00	00.00	00.00
Other Factory Expenses.....	00.00	A	00.00	00.00	00.00	00.00
	$000.00		$000.00	$000.00	$000.00	$000.00
Productive Labor...........	$0,000.00		$0,000.00	$000.00	$000.00	$000.00
Burden Percentage.........	00.0%		00.0%	00.0%	00.0%	00.0%

A. Productive Labor.
B. Floor Area.
C. Valuation.
D. Horse Power Used.
S. Specific Charge Against Department.

FIGURE 137.—Analysis of Factors Making Up Shop Burden

proved into the monthly balance sheets. This is provided for by the establishment of a private ledger and a works ledger which must balance each other through controlling accounts. The accumulated cost figures are absorbed by the works ledger and the accumulated financial figures by the private ledger, thus assuring that each balances the other and that all transactions are absorbed by one or the other.

Establishment of Private and Works Ledgers

To correctly establish the cost plan and the proof of the works ledger, it is necessary to provide two controlling accounts which will represent the total investment in the form of raw

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Folding and Clipping	Power	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Total Burden			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]	Productive Labor		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]	Percentage of Burden to Productive Labor			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				

Figure 198 Complete Burden Statement and Distribution

materials, parts and product in process, finished product and factory expenses.

One of these accounts is carried upon the private ledger and is known as the works ledger controlling account, symbol B. The other controlling account is known as the private ledger controlling account, and is carried upon the works ledger having the same symbol B. These two accounts act as controlling accounts to each other and at the end of each month, their balances should be in agreement.

At the beginning of the year the works ledger controlling account, symbol B, in the private ledger is charged with the total amount of the inventory. Through the year this account is charged with the total of all purchases of material, payroll and factory expenses. It is credited with the cost of all goods shipped and charged with the cost of any goods returned. The balance of this account will, therefore, at all times represent the total of raw materials, work in process and finished stock inventories.

The foregoing describes in general the methods to be us in order to establish the accounts necessary for a monthly loss and gain statement supported by cost records as carried in the works ledger and controlled by the general books. The control of costs is thus obtained through proof of the balance in the various accounts in the works ledger in the following manner:

1 When the balance of the various inventory accounts agrees with the physical inventory accounts, a proof is furnished that the value of materials consumed is substantially in agreement with the cost of the material.

2 When the aggregate of the various factory overhead expense accounts, as a total, which are debited under symbol M1-15, is in substantial agreement with the aggregate amount of credits which have been charged to the work in process burden, a proof is established that a proper percentage of burden expense has been used.

Considering the foregoing, it should be held in mind that the works ledger will give proof of the accuracy of the cost records and through these the loss and gain statement. Should there arise any question as to the amounts shown in the cost records, an analysis may be quickly made and traced through either the material, labor or expense accounts. The entire plan is subjected to direct proof when physical inventories are taken at different periods of the year.

Private Ledger Accounts

Figure 139 is a chart of private ledger accounts, covering the accounts of a table factory. The accounting for this plant will be used as an example to demonstrate the methods recommended. It will be noted that the order of the accounts in the ledger is

CHART OF PRIVATE LEDGER ACCOUNTS

	ASSETS					LIABILITIES					REVENUE AND EXPENSE							
	A CURRENT	B INVENTORY	C FIXED	D DEFERRED		E CURRENT	F	G RESERVE	H CAPITAL		J SALES	K DEDUCTIONS	L COST OF SHIPMENTS	M	N ADMINISTRATIVE EXPENSE	O SELLING EXPENSE	P OTHER	
1	CASH IN OFFICE		LAND	INSURANCE UNEXPIRED	1	ACCOUNTS PAYABLE WAGES			CAPITAL STOCK	1	MERCHANDISE SALES	FREIGHT ALLOWED	FACTORY COST OF SHIPMENTS		EXECUTIVE SALARIES	SELLING SALARIES & COMMISSIONS	INTEREST RECEIVED	1
2	CASH IN BANK		OLD BUILDINGS	AMERICAN FURN. ASSOC. DUES	2	ACCOUNTS PAYABLE TRADE			SURPLUS	2			COMMERCIAL COST OF SHIPMENTS		OFFICE SALARIES	TRAVELING EXPENSE	DISCOUNTS RECEIVED	2
3	ACCOUNTS RECEIVABLE CUSTOMERS		NEW BUILDINGS		3	NOTES PAYABLE				3		TRADE DISCOUNT ALLOWED			TELEGRAPH TELEPHONE POSTAGE & TAX STAMPS	PHOTOS ELECTROS CATALOGUES	RENTS	3
4	RESERVE FOR TRADE DISCOUNT		MACHINERY AND EQUIPMENT		4				GROSS PROFIT	4		OTHER DEDUCTIONS			STATIONERY PRINTING OFFICE SUPPLIES	ADVERTISING	WOOD SALES	4
5	NOTES RECEIVABLE		TOOLS		5			RESERVE FOR EMPLOYERS LIABILITY	MFG. PROFIT	5		RETURNS AND ALLOWANCES			GENERAL OFFICE EXPENSE	CREDITS AND COLLECTIONS		5
6	NOTES RECEIVABLE DISCOUNTED		PHOTO EQUIPMENT		6	ACCRUED TAXES			NET PROFIT	6					OTHER ADMINISTRATIVE EXPENSES	BAD DEBTS	RESALES	6
7	ACCOUNTS RECEIVABLE PERSONAL		OFFICE FURNITURE & EQUIPMENT		7				DIVIDENDS PAID	7					PATRIOTIC FUND	BRANCH RENT		7
8				LOCAL HOMES CO. STOCK	8				FEDERAL TAXES PAID	8						FREIGHT ON RETURNS	INTEREST PAID	8
9					9					9							DISCOUNTS ALLOWED	9
10	TRADE ACCEPTANCES RECEIVABLE			INTEREST PREPAID	10	TRADE ACCEPTANCES PAYABLE				10							DWELLING REAL ESTATE EXPENSE	10
11	LIBERTY BONDS			BRANCH RENT PREPAID	11	ACCRUED INTEREST				11							WOOD DELIVERY EXPENSE	11
12	WAR SAVINGS STAMPS				12					12								12
13		FACTORY LEDGER CONTROLLING ACCOUNT			13					13								13
14		FINISHED STOCK			14					14								14
15		SAMPLES	RESERVE FOR DEPRECIATION		15					15								15
20					20					20						RESERVE FOR COMMERCIAL BURDEN		20

FIGURE 139.—Chart for Private Ledger Accounts

the same as that in which they appear on the statements shown later. Assets are arranged in order of the availability and are followed by liabilities in order of priority. These in turn are followed by the various revenue and expense accounts, arranged in logical order. This arrangement greatly simplifies the preparation of all statements, reducing it to a simple matter of copying amounts from the ledger.

Any of the accounts as shown may be subdivided and the subdivision indicated by placing an additional letter after the ac-

count symbol, thus A3, accounts receivable—customers, may be sub-divided: A3a Accounts Receivable—City; A3b Accounts Receivable—Foreign; etc.

The account symbol is placed upon the outer upper corner of the ledger sheet, and the sheets arranged alphabetically in the ledger by sections. In each subdivision thus established the accounts are arranged numerically.

While most of the accounts as listed are self-explanatory, the operation of the following acounts will be explained in detail.

A4—Reserve for Trade Discount

Debit	*Credit*
From Record of Cash Received Total trade discount deducted from remittances during month	From Customers' Ledger Total of trade discount to be allowed on outstanding Accounts Receivable at begining of period
	From Sales Record Total of trade discount deductible from invoices for month Opposing debit K3 Trade discount

Balance

Represents amount of trade discount deductible from Accounts Receivable

A6—Notes Receivable Discounted

Debit	*Credit*
From Journal Amount of discounted notes paid by maker Opposing credit A5 Notes Receivable Amount of discounted notes dishonored by	From Record of Cash Received Amount of Notes Receivable discounted

maker and paid by Company	
Opposing credit	
Cr. Cash	
————	————

Balance:

Represents total contingent liability for notes endorsed and discounted.

B—Works Ledger Controlling Account

Debit	*Credit*
From Inventory: The total value of raw materials, goods in process and finished product	From Recapitulation of Shipments: The total cost of shipments for month.
————	————
From Voucher Register: Total value of materials purchased, plus freight	Miscellaneous: Items to be debited to accounts in general ledger
————	————
From Payroll: Total factory payroll	
————	————
From Journal: Depreciation, insurance and taxes accruing each month	
————	————
From Credit Memos: Cost of goods returned and put in stock	
————	————

Balance:

The total inventory at end of each month

C15—RESERVE FOR DEPRECIATION

Debit	*Credit*
From Journal Amount of depreciation written off machinery, tools or buildings scrapped or sold Opposing credit — Property account	From Journal Monthly depreciation accruing on all fixed property Opposing debit—Depreciation (works ledger)

Balance

Represents depreciation from cost of all property items. It is carried on statements as a deduction from Fixed Assets.

D1—INSURANCE UNEXPIRED

Debit	*Credit*
From Journal Amount of unexpired insurance at opening of records	From Journal Amount of insurance expiring each month, as determined from (*a*) an analysis of insurance policies, or (*b*) an estimate based on figures of prior years Opposing debit B13 Works ledger insurance
From Voucher Journal Total insurance premiums paid	From Cash Received Refund of premiums and insurance dividends on mutual policies

Balance

Represents value of prepaid insurance. At end of fiscal period a statement should be obtained from insurance companies and an adjusting entry made correcting balances. Corresponding entry insurance (works ledger)

D10—Prepaid Interest

Debit	*Credit*
From Journal Amount of interest prepaid at opening of records	From Journal Interest accruing monthly Opposing debit P8 Interest paid
From Voucher Journal Interest paid	

Balance

Represents amount of prepaid interest. This account is identical with E11 except that it is used only in case a debit balance arises

D11—Branch Rent Account

Debit	*Credit*
From Voucher Journal Rent paid	From Journal Rent accruing monthly

Balance

May be either a debit representing prepaid rent or a credit representing rent accrued and not paid

E6—Accrued Taxes

Debit	*Credit*
From Voucher Journal State and local taxes paid	From Journal Taxes due and unpaid Taxes accruing each month, based on estimate from last years' figures, plus reasonable allowance for increase. Interest acruing monthly Opposing debit B13 Works ledger taxes

Balance

Represents unpaid taxes owed

E11—ACCRUED INTEREST

Debit	*Credit*
From Voucher Journal Interest paid	From Journal Interest due on outstanding notes at opening of records Opposing debit P8 Interest paid

Balance

Represents accumulated unpaid interest. This account is identical with account D10, except latter is used when a debit balance arises.

H5—MANUFACTURING PROFIT

Debit	*Credit*
From Journal Commercial cost of shipments Opposing credit L2 Commercial cost of shipments.	From Journal Total gross profit Opposing debit Gross profit

Balance

Before closing into net profit represents manufacturing profit for year

This account is used only to close books at end of fiscal period

H4—GROSS PROFIT

Debit	*Credit*
From Journal Cost of sales for year Opposing credits L1 Factory cost of sales	From Journal Net sales for year after deductions K1 to K5 Opposing debits J1 Sales

From Journal
Balance
Opposing credit
115 Manufacturing profit

Balance

Before closing represents gross profit for year. Used only to close books at end of fiscal period

110—Net Profit

Debit

From Journal
Other expenditures
Opposing credit
Acounts P8 to P11 inclusive

From Journal
Balance
Opposing credit
Surplus

Credit

From Journal
Manufacturing profit for year
Opposing debit
Manufacturing profit

Other Income
Opposing debits
Various income accounts P1 to P4 inclusive

Balance

Before closing represents net profit or loss for year. Used only to close books at end of fiscal period

118—Federal Taxes Paid

Debit

From Voucher Journal
Amount of Federal taxes paid

Credit

From Journal
At end of year
Total of account
Opposing debit
Surplus

* [illegible] separate from other expenses on account of Federal Income [illegible] it as a direct charge against surplus. It should be deducted [illegible] State income tax.

J1—MERCHANDISE SALES

Debit	*Credit*
From Journal	From Invoices
At close of period	Merchandise sales
Deductions from sales as shown by	Opposing debit
K1 Out freight	Accounts receivable
K3 Trade discount	
K4 Other deductions	
K5 Returns and allowances	
Opposing Credit	
K1, K3, K4 and K5	
From Journal	
Net Sales as shown by balance	
Opposing credit	
Gross profit	

Balance

Represents gross sales to date after closing net sales for year

L1—FACTORY COST OF SHIPMENTS

Debit	*Credit*
From recapitulation of invoices for the month	From Inventory
Cost of shipments for month	Amount necessary to balance work in process account with physical inventory if inventory is higher
	Opposing debit
	Work in process (works ledger)
	From Journal
	Balance of account after adjusting inventory
	Opposing debit
	Manufacturing profit

Credit or Debit

From Inventory

Amount necessary to balance work in process with physical inventory if physical inventory is lower	Opposing credit Work in process (works ledger)

Balance

Represents total factory cost of shipments to date

L2—COMMERCIAL COST OF SHIPMENTS

Debit	*Credit*
From Journal Estimated percentage of factory cost of sales Opposing credit Reserve for commercial burden	From Journal Total of account after adjusting Opposing debit Manufacturing profit

Debit or Credit

Difference between total of balances in expense accounts (N1 to O8 inclusive) and reserve for commercial burden account. Corresponding entry, reserve for commercial burden.

Balance

Represents commercial cost of shipments

N1 TO O8—COMMERCIAL EXPENSE

Debit	*Credit*
From Voucher Journal Commercial expense items	From Journal Total of each account at close of fiscal period Opposing debit Reserve for commercial burden

Note: If preferred, total expenses for month may be charged to sales instead of using a percentage of factory costs

Balance

Is expense to date

O20—RESERVE FOR COMMERCIAL BURDEN

Debit	*Credit*
From Journal Total of expense accounts N1 to O8 at end of fiscal year Opposing credit Various expense accounts	From Journal *Fixed percentage of factory cost of sales Opposing debit Commercial cost of shipments

Debit and Credit

At end of year. Difference between balance of account and expense accounts N1 to O8. Corresponding entry commercial cost of shipments

Balance

Represents amount of commercial expense charged to cost of shipments

P3—RENTALS EARNED

Debit	*Credit*
From Journal At end of period Total of account Opposing credit Net profit	From Journal Rents accruing monthly Opposing debit Rents receivable

Balance

Represents income from rented property

Miscellaneous income accounts P1 to 4 are closed into net profit at end of period

Miscellaneous expense acounts P8 to 11 are closed into net profit at end of period

* As alternative total expenses for each month may be charged.

Works Ledger Accounts

The following represents the works ledger accounts comparing to the private ledger accounts shown in Figure 139.

Controlling Account—Symbol B

Inventory Accounts—Symbol B

1 Lumber and Dimension Stock
2 Crating Lumber
3 Veneers
4 Hardware and Miscellaneous
5 Glue
6 Sand Paper
7 Finishing Materials
8 Packing Materials
9*a* In Process Materials
9*b* In Process Labor
9*c* In Process Burden

Expense Account—Symbol M

1 Superintendent and Foreman
2 Departmental Non-Productive Labor
3 Repairs to Plant
4 Repairs to Equipment
5 Repairs to Tables
6 Shipping Expense
7 Drayage
8 Yard Expense
9 Expense Materials
10 Power, Light, Heat, Protection
11 Insurance
12 Taxes
13 Depreciation
14 Other Factory Expenses
15 Reserve for Burden

Miscellaneous

No symbol has been designated for the miscellaneous account and it is used only as a means of transferring items which appear in the works ledger from time to time but which are for-

eign to the cost records and should be direct charges to some general ledger account, other than listed in the works ledger.

Form of the Works Ledger

Figure 140 shows a special form designed for a works ledger, consisting of two full sheets and a half-double-side insert. While this form is very easily utilized, it is expensive, and single ledger sheets for each account of the works ledger may be used in the same manner as the private or general ledger is maintained.

Inventory Accounts

The inventory accounts as detailed in the foregoing are charged with the result of physical inventories when taken. For each succeeding month they are charged with all material purchased and credited with the quantities of materials consumed, which will be determined by the reports provided through the material requisitions (Figure 33). The balance appearing in these accounts at the end of each month represent the inventory value of raw materials on hand, the amount of material, labor and burden in process and amount of material, labor and burden on hand of finished product, and the amount of burden unabsorbed or overapplied.

Schedule of Accounts by Symbol and What Each Represents

B1—Lumber and Dimension Stock

All kinds of lumber, including dimension stock, except crating lumber.

B2—Crating Lumber

All kinds of crating lumber used for crating and packing of the tables.

B3—Veneers

Flitch, dimensions, cores, and tape veneers.

B4—Hardware and Miscellaneous

Wood screws, wire nails, brass feet, drawer pulls, posts and nuts, casters, headless rods, ink wells, joint fasteners, brads, corner brackets, domes, ornaments, desk lifts, and locks.

B5—Glue

Animal glue.

B6—Sand Paper

Garnet cloth, all brands of sand paper and emery cloth.

WORKS LEDGER

MANUFACTURING COMPANY

MONTH OF

Date	Journal Entry No.	Description	Controlling Account Debit	Controlling Account Credit	Inventory Accounts: [illegible] Debit	[illegible] Credit	Crating Lumber Debit	Crating Lumber Credit	Veneers Debit	Veneers Credit	Hardware and Misc. Debit	Hardware and Misc. Credit	Glue Debit	Glue Credit

WORKS LEDGER

MANUFACTURING CO.

MONTH OF

Inventory Accounts: Sandpaper Debit	Sandpaper Credit	Finishing Materials Debit	Finishing Materials Credit	Goods in Process Debit: Material	Labor	Burden	Goods in Process Credit: Material	Labor	Burden

WORKS LEDGER

MANUFACTURING CO.

MONTH OF

Expense Accounts: [illegible] Debit	Credit	[illegible] Debit	Credit	[illegible] Debit	Credit	[illegible] Debit	Credit	[illegible] Debit	Credit	[illegible] Debit	Credit

WORKS LEDGER

[redacted] MANUFACTURING COMPANY

MONTH OF

EXPENSE ACCOUNTS														FACTORY COST OF SHIPMENTS					
DRAYAGE		YARD EXPENSE		EXPENSE MATERIALS		P. H. L. AND PROTECTION		INSURANCE, TAXES, DEPRECIATION				RESERVE FOR FCTY. BURDEN		DEBIT			CREDIT		
DEBIT	CREDIT	DEBIT	CREDIT	DEBIT	CREDIT	DEBIT	CREDIT	SYM	DEBIT	SYM	CREDIT	DEBIT	CREDIT	MATERIAL	LABOR	BURDEN	MATERIAL	LABOR	BURDEN

FIGURE 140.—Form for Works Ledger

B7—Finishing Materials

Varnish, liquid and powder stains, fillers, oils, shellac, naphtha, ammonia, rotten stone, turpentine, dryer, alcohol, putty, pumice stone, wax and all pigments.

B8—Packing Materials

Envelopes for parts, fibre paper, kraft paper, excelsior, pads, tags and twine.

B9—In Process

All completed tables and tables and parts under construction.

M1-15

Non-productive labor of the following productive departments:

Cutting	Veneering
Machining	Yard
Sanding	Stock Room
Assembling	Shipping
Finishing	

Other Non-Productive Labor:

Supervision
Watchman
Repairs and Maintenance of Building
Repairs and Maintenance of Machinery
Repairs of Tables

Expense Supplies

Repair Supplies
Shipping Supplies
Power and Heat Supplies
Finishing Tools and Supplies
Other Tools and Supplies

Other Expense Accounts:

Fire Insurance
Liability Insurance
Taxes
Depreciation
Sample Tables and Parts
Reserve for Factory Burden

List of Charges to Be Made to the Following Factory Expense Accounts

M4—Repairs to Equipment

Belting, knives, drills, files, solder, jointer and planer knives, band and circular saws, emery wheels, steel drill rods, cement and bricks, pipe fittings, machine castings, pulleys, electrical supplies, and shafting.

M6—Expense Shipping

Shipping tags and cards.

M9—Expense Materials

Waste, rubbing felt, sponges, steel wool, finishing wax, newspapers, brooms, belt dressings, clock slips, gasoline, kerosene, toilet articles, water bills, medicines, factory stationery supplies.

M10—Power and Heat Supplies

Coal, wood, oils, lubricants, etc.

Summary of Works Ledger Entries

1 Analysis of voucher register (see later) for purchases of raw material and supplies

2 Recapitulation of material requisitions to obtain materials and supplies consumed

3 Distribution of productive payroll

4 Work in process, material, labor and burden obtained from credits to various raw material inventory accounts

5 Factory expenses obtained from factory ledger accounts M1-15

6 Factory cost of shipments determined from invoices for the month

7 Miscellaneous transfers

Details of Works Ledger Entries

1 The analysis of the voucher register for purchases made during the month will merely mean the totaling of each individual column as the register is subdivided into columns, each of which is headed up with the same classification as appears in the Works Ledger for raw materials.

2 Material requisitions are summarized according to the classification of materials appearing thereon (this work should be kept up currently).

3 The productive payroll is charged in a net figure to work in process labor. The amount is determined by analysis of the payroll (Figure 141) in accordance with the postings made through summarizing the service cards. Non-productive labor is charged to the various expense accounts.

4 Work in process—material, labor and burden. Charges to work in process, material, are obtained from credits made to the various raw material inventory accounts. Charges to work in process—labor, are obtained from the productive payroll as outlined above. Charges to work in process—burden, are obtained by applying a certain percentage of the direct labor to the cost.

5 Factory expenses are secured when the current charge is made as they appear in the factory ledger, under the account heading, Factory Expenses, M1-15.

6 The factory costs of shipment are determined by summarizing from the invoices the various classes of tables shipped during the month and multiplying each class by the costs obtainable.

7 Miscellaneous entries will appear in the works ledger only at such time when items foreign to the cost of product make their appearance in the various inventory accounts. These items through the miscellaneous column are transferred to their legitimate accounts in the private ledger. An explanation of certain works ledger accounts follows:

General Ledger Controlling Account-Symbol B

Debit	*Credit*
From Factory Cost of Shipments The total cost value of shipments, tables, for the month	From Inventory The total value of raw materials, tables in process and finished at the beginning of the period

FIGURE 141. Form for Payroll Analysis

Debit	Credit
Miscellaneous Such items as appear in the miscellaneous account which are debited to accounts in the private ledger	From Voucher Register Total value of materials purchased each month, plus freight
	From Payroll Total value of factory payroll each month
	From Journal Total depreciation to be written off each month. Taxes accruing during month. Insurance used during month.
	From Credit Memos Cost of goods returned and put in stock.

Balance

Represents the total value of the inventory of raw materials, tables and parts in process, finished product and factory expenses, unabsorbed or overapplied.

Note. The Private ledger account in the works ledger is the controlling account for all accounts included therein. The total of the balances of all other works ledger accounts should be in agreement with the balance appearing in the controlling account.

[illegible] Lumber and Dimension Stock

Debit	*Credit*
From Physical Inventory Valuation at the beginning of the period	From Recapitulation of Material Requisitions Total value of lumber and dimension stock consumed during the month.

Opposing entry
Work in process—material

From Voucher Register
Total monthly purchases
Opposing entry
Private ledger Symbol B

Balance

Represents the inventory value of Lumber and Dimension stock on hand at the end of the month.

Additional accounts will be operated from similar entries under the following titles:

B2 Crating Lumber
B3 Veneers
B4 Hardware and Miscellaneous
B5 Glue
B6 Sand Paper
B7 Finishing Material
B8 Packing Material

B9a WORK IN PROCESS—MATERIAL

Debit	*Credit*
From Physical Inventory Valuation at the beginning of the period.	From Recapitulation of Finished Product Total value of material contained in tables shipped during the month. Opposing entry Private ledger control
From Material Requisitions Total value of materials consumed during the month Opposing entry Various raw material accounts	

Balance

Represents value of materials in process at the end of each month

Work in Process — Labor

Debit	*Credit*
From Physical Inventory Valuation at the beginning of the period	From Recapitulation of Shipments Total value of labor in tables shipped during month. Opposing entry Private ledger control
From Labor Distribution Total value of productive labor as reported by worker cards Opposing entry Private ledger control	

Balance

Represents labor in process at the end of each month

Work in Process — Burden

Debit	*Credit*
From Physical Inventory [illegible]	From Recapitulation of Finished Product The total value of burden applied on tables shipped during the month. Opposing entry Private ledger control
[illegible] during the month.	

Opposing entry
Factory expenses—burden

Balance

Represents value of burden in process.

FACTORY EXPENSES AND BURDEN RESERVE

Debit	*Credit*
From Labor Distribution Non-productive labor shown by service cards and factory salary charges for the month	From Works Ledger Entry Estimate of burden applicable to productive labor charged to work in process based on experience of prior years Opposing entry Work in process-burden
From Voucher Journal Total of charges to account of factory expenses M 1-14	
From Journal Depreciation, taxes and insurance accruing during month Opposing entry Private ledger—Symbol B	

Balance

Represents the amount of burden unabsorbed or overapplied. A credit balance would indicate that the expenses were overabsorbed, while a debit balance would indicate that the expenses were in excess of the amount applied as burden.

VOUCHER AND CHECK REGISTER

As indicated in the foregoing, in this particular application

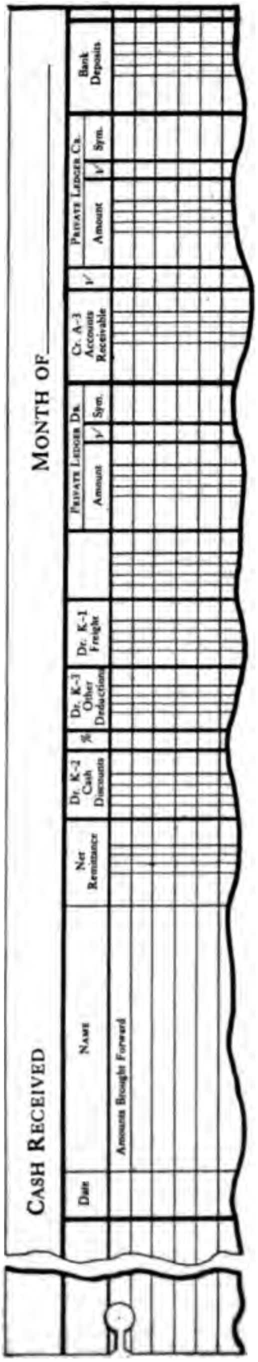

FIGURE 143.—Form for Recording Receipts

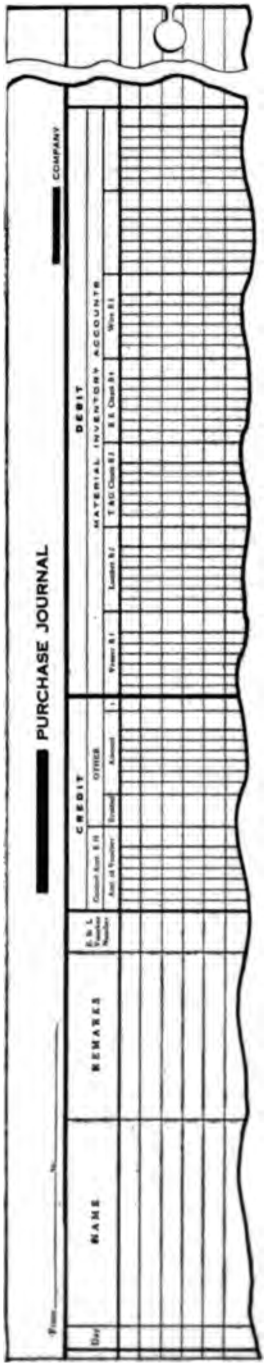

FIGURE 144.—Form for Purchase Journal

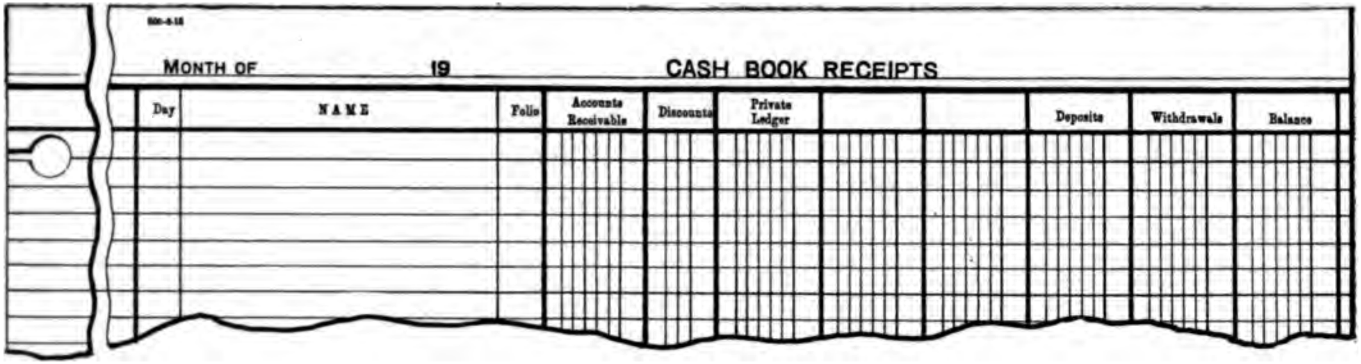

FIGURE 145.—Form for Cash Book-Receipts

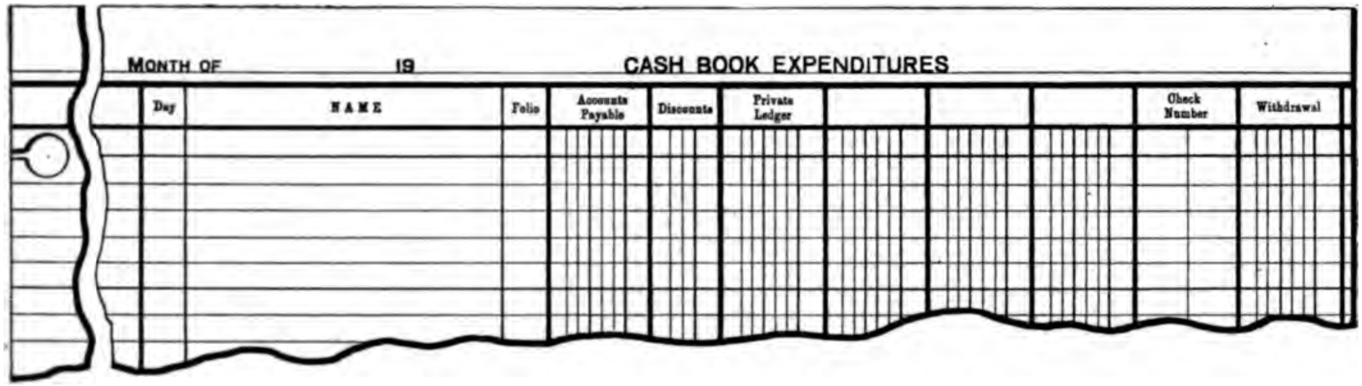

FIGURE 146.—Form for Cash Book-Expenditures

Book Value	750.00	
Sold for	700.00	
Additional Depreciation	$50.00	

Entries

	Debit	Credit
Cash received for machine.............	$700.00	
Depreciation, (Works Ledger Control)...	50.00	
Reserve for Depreciation	250.00	
Machinery		$1,000.00

In case too much depreciation has been written off there will be a credit to the Depreciation Account in the Works Ledger in place of debit.

Monthly Statements

The following statements should be prepared each month:

- Financial Statement (Figures 147 and 148)
- Factory Ledger Balance Sheet (Figure 149)
- Loss and Gain Statement (Figure 150)
- Analysis of Commercial Expense (Figure 151)
- Analysis of Factory Expense (Figure 152)
- Graphic Reports

These statements are made in comparative monthly form showing the results of operations month by month, an extra column being provided for yearly totals and final results after closings the books.

The accounts appear on the ledger in exactly the same order in which the items appear on the statements and the mechanical work of taking off the statement is very simple.

A few items on the statements may require detailed explanation.

The item of unabsorbed or overapplied burden (the latter carried in red as a deduction) is the difference between the debit balances in the various expense accounts and the credit balances in the reserve for burden account. At the same time it serves as a check on the accuracy of the predetermined burden rates.

The Profit to Date item carried among the capital assets is likewise the net difference between the debits and credit balances

FINANCIAL STATEMENT

	ASSETS	JAN.	FEB.	MAR.	APRIL	MAY	
	CURRENT						
A1	CASH IN OFFICE.						
A2	" " BANK.						
A3	ACCOUNTS REC. CUSTOMER.						
(A4)	(RESERVE FOR TRADE DISC.)						
A5	NOTES RECEIVABLE.						
(A6)	(" " DISCOUNTED)						
A7	ACCOUNTS " PERSONAL.						
A10	TRADE ACCEPTANCES REC.						
A11	LIBERTY BONDS.						
A12	WAR SAVING STAMPS.						
	TOTAL CURRENT						
	INVENTORY						
B	WORKS LEDGER.						
	A. RAW MATERIAL.						
	B. WORK IN PROCESS.						
	C. UNABSORBED BURDEN.						
	(OVERAPPLIED ")						
B15	SAMPLES.						
	UNABSORBED COM. BURDEN.						
	(OVERAPPLIED " ")						
	TOTAL INVENTORY						
	" CURRENT & INV.						
	FIXED AND DEFERRED						
C1	LAND						
C2	OLD BUILDINGS.						
C3	NEW "						
C4	MACHINERY & EQUIPMENT.						
C5	TOOLS.						
C6	PHOTO EQUIPMENT.						
C7	OFFICE FURN. & EQUIP.						
	TOTAL FIXED ASSETS.						
(C15)	(LESS DEPRECIATION)						
	NET FIXED ASSETS.						
D1	INSURANCE UNEXPIRED.						
D2	AM. FURN. ASSOC. DUES.						
D8	LOCAL HOMES CO. STOCK.						
D10	INTEREST PREPAID.						
D11	BRANCH RENT PREPAID						
	TOTAL FIXED AND DEF.						
	TOTAL ASSETS.						

NOTE:-Brackets indicate Red Ink.

FIGURE 147.—Arrangement of Items for Financial Statement (Assets)

FACTORY LEDGER BALANCE SHEET							
		JAN.	FEB.	MARCH	APRIL	MAY	
	RAW MATERIAL						
B1	LUMBER & DIM. STOCK						
B2	CRATING LUMBER.						
B3	VENEERS						
B4	HARDWARE & MISC.						
B5	GLUE						
B6	SANDPAPER						
B7	FINISHING MATERIAL						
B8	PACKING MATERIAL						
	TOTAL MATERIAL INV.						
B9	WORK IN PROCESS. A. MATERIAL B. LABOR C. BURDEN						
	TOTAL IN PROCESS						
	UNABSORBED FACTORY BURDEN (OVERAPPLIED " ") ...In Red Ink...						
B	TOTAL INVENTORY (WORKS LEDGER CONTR.)						

FIGURE 149.—Form for Factory Ledger Balance Sheet

TRADING AND PROFIT AND LOSS STATEMENT							
		JAN.	FEB.	MARCH	APRIL	MAY	
J1	MERCHANDISE SALES						
	LESS						
K1	FREIGHT ALLOWED						
K3	TRADE DISCOUNT						
K4	OTHER DEDUCTIONS						
K5	RETURNS AND ALLOWANCES						
	TOTAL DEDUCTIONS						
	TOTAL NET SALES						
	LESS						
	FACTORY COST OF SALES						
	ADMINISTRATION COST OF SALES						
	TOTAL COST OF SALES						
	GROSS OPERATING PROFIT						
	OTHER REVENUE						
P1	INTEREST RECEIVED						
P2	DISCOUNT RECEIVED						
P3	RENTS						
P4	WOOD SALES						
P6	RESALES~PROFIT ON						
	TOTAL OTHER REVENUE						
	GROSS PROFIT						
	OTHER EXPENSES						
P8	INTEREST PAID						
P9	DISCOUNT ALLOWED-CASH						
P10	DWELLING R.E. EXPENSE						
P11	WOOD DELIVERY EXPENSE						
	TOTAL OTHER EXPENSES						
	NET PROFIT THIS MONTH						
	PROFIT THIS YEAR						

FIGURE 150.—Form for Profit and Loss Statement

ANALYSIS OF COMMERCIAL EXPENSE							
	ADMINISTRATIVE	JAN.	FEB.	MAR.	APR.	MAY	
N1	EXECUTIVE SALARIES						
N2	OFFICE SALARIES						
N3a	TEL. TELEG., POSTAGE						
N3b	TAX STAMPS						
N4	STAT., OFFICE SUPPLIES						
N5	GENERAL OFFICE EXPENSE						
N6	OTHER ADMIN. EXPENSE						
N7	PATRIOTIC FUND						
	TOTAL ADMIN. EXPENSE						
	SELLING EXPENSE						
O1	SELLING SALARIES, COM.						
O2	TRAVELING EXPENSES						
O3	PHOTOS, ELECTROS, CAT.						
O4	ADVERTISING						
O5	CREDITS, COLLECTIONS						
O6	BAD DEBTS						
O7	BRANCH RENT						
O8	FREIGHT ON RETURNS						
	TOTAL SELLING EXPENSE						
	TOTAL COMMERC. EXPENSE						
	CHARGED TO COST OF SALES						
	TOTAL EXPENSE TO DATE						
	RESERVE FOR BURDEN						
	UNABSORBED BURDEN (OVERAPPLIED BURDEN)						
	In Red Ink						

FIGURE 151.—Form for Analysis of Commercial Expense

ANALYSIS OF FACTORY EXPENSE

		JAN.	FEB.	MAR.	APR.	MAY	
M 1	SUPERIN. AND FOREMEN						
M 2	NON-PRODUCTIVE LABOR						
M 3	REPARIS TO PLANT						
M 4	REPAIRS TO EQUIPMENT						
M 5	REPAIRS TO TABLES						
M 6	SHIPPING EXPENSES						
M 7	DRAYAGE						
M 8	YARD EXPENSE						
M 9	EXPENSE MATERIALS						
M 10	POWER, HEAT, LIGHT, PRO.						
M 11	INSURANCE						
M 12	TAXES						
M 13	DEPRECIATION						
M 14	OTHER FACTORY EXPENSES						
	TOTAL FACTORY EXPENSE						
	CHARGED INTO PROCESS						
	FACTORY EXPENSE TO DATE						
	RESERVE FOR BURDEN						
	UNABSORBED BURDEN						
	(OVERAPPLIED BURDEN)						

Fig. [illegible] Form for Analysis of Factory Expense

in the revenue section of the private ledger. It represents the net profit to date and is considered as an addition to the capital.

Federal taxes and dividends paid are by Federal requirements direct charges against surplus and are, therefore, carried as a deduction from the capital assets.

Use of Statements

Following are a few brief suggestions on the use of these statements after they are submitted to the executives:

Financial Statement. This statement lists the assets in order of their availability and the liabilities in order of their priority with sub-totals showing the totals of current liabilities and current assets.

A comparison of the current liabilities with the current assets available to meet them gives a very valuable insight into the financial condition of the business.

An examination of this statement will indicate exactly where the working capital is invested and will serve as a check upon investing too much capital in raw material and inventories.

Factory Ledger Balance Sheet. This statement shows the details of the inventories which are summarized on the financial statement. It should be watched with two ideas in mind.

1 The amounts of the various inventories should be kept as low as practicable in order to prevent overbuying and tying up working capital unnecessarily

2 The amounts should be carefully compared with the actual amount of materials in the plant as any variation between the physical and book inventories must result from an error in the cost figures which should be investigated and corrected.

The three work in process accounts particularly should be watched and a comparison made between the proportion of material, labor and burden in process, from month to month. Charges to these accounts may be relied upon as correct if material requisitions are properly handled. Any variation must, therefore, come from an error in crediting these accounts with the cost of shipments and must therefore reflect an error in the cost figures. If the book inventory exceeds the physical inventory, it is evident that the credits have been too small. That is, the cost of shipments has been figured too low and the profit

as shown by the books is too high. If the physical inventory is greater than that shown by the books, cost of shipments have been figured too high and the actual profits are in excess of those shown on books and statements.

The division of these work in process accounts into material, labor, and burden facilitates the location of errors.

Credits shed or overapplied burden should show only a small balance. The continued accumulation of any large amount under either of these headings indicates a necessity of changing the burden rate.

Profit and Loss Statement. This statement is self-explanatory and affords a monthly comparison of sales, cost of sales, operating profit and miscellaneous items of income and expenditure. The proportion of profits to sales gives a check upon the relative sales in profitable lines. The amount of cash discount allowed should also be watched and kept as low as practicable.

Expense Statement. The monthly expenses as shown by these statements should be carefully compared, both in detail and total with that shown for previous months. Any material variations should be noted and investigated.

The amounts shown on these statements represents an outlay for intangible items and any reduction or saving which may be effected is clear profit.

Graphic Reports. A series of graphic reports should also be put in operation, showing in graphic form the productive and non-productive labor and bonus for each department. These reports should be watched from month to month, noting the relation of non-productive and productive labor, and the relations between the monthly productive labor and bonus earned. From an inspection of these sheets a very good idea of the relative efficiency of the various departments may be obtained.

Accumulation of Cost in Factory

In order to show clearly the methods by which costs are accumulated, the progress of an order through the plant will be briefly outlined, although discussed in detail in earlier chapters.

Orders are originated in the Planning Department and are sent to the factory in the form of tags (production orders, Figures [illegible] and [illegible]), one for each part, with separate tags for the

ing and finishing.

usage of the tag, the amount of lumber required is es-

timated and delivered to the cut-off saws. These saws cut to advantage and work on several orders at once. Therefore, it is impracticable to distribute the cost of cutting off directly to the order or part worked upon. After being cut off, the lumber is sorted and the cost of further operations can be definitely ascertained.

Any error in estimating the amount of lumber required for an order is corrected as soon as the material reaches the glue room. Any lumber cut in excess of amount required is returned and any shortage made up. This item is of importance in cost accumulation and in figuring the waste as detailed in previous and the following pages.

From the cut-off saws the lumber goes through the rip-saws, skinner and planer, lineal jointer and glue room, in the order named.

As each man starts work on an order he punches the time on a job-time card (Figure 52) upon which is also given the date, order number, unit symbol and part symbol, and the number of parts covered. When more than one man works on a machine, the quantity will be shown in red upon the helper's card. This card is again punched with the time the man stops work, and after the quantity is inserted by the piece counter, the card is sent to the Planning Department for use in posting the control board, and figuring the payroll and costs. After being extended to show labor costs, time cards are sorted and filed under unit and part symbols until order is completed.

Up to the time an order leaves the glue room it is kept together so that it is possible to figure the cost of the order up to that point. After leaving the glue room there is a possibility of part of the material being stored for future use or being diverted to some other order. This possibility is considered in the method of figuring table costs.

As units are completed and packed, a crating report is made out, showing the number of each table sent to the warehouse. This report is sent to the Planning Department and the number of units packed noted upon the warehouse inventory cards.

All material used is obtained from the storeroom and yard upon material requisition. These requisitions are later sent to the Planning Department where they are entered upon the perpetual inventory records and filed until the end of the month when they are totaled and the value of all material put into work summarized for the use of the bookkeeper.

Details of Cost Compilation

Material. A material summary card (Figure 153) is filled out for each unit of product giving in detail the quantity of material required. Under Lumber, Veneer and Finishing Material separate columns have been provided for use in figuring the material cost of tables in three different finishes. The quantity of material should be entered in ink. The price and value should be extended in pencil to facilitate changes necessitated by variations in the market values of material.

The amount of labor and hardware required for a unit may be readily ascertained. The amount of glue is figured from the number of square feet glued. The amount of finishing material is estimated from the surface feet to be finished as follows: Test runs are made for each of the finishing operations and from these tests the amount of material necessary to cover one surface foot is ascertained in decimals of a gallon. The surface required to be covered for a table is recapped as follows:

	Paint	1st Coater	2nd Coater
Top	2.5	5.0	2.5
Legs	1.0	1.0	1.0
Shelf	1.6	3.2	1.6
Total	5.1	9.2	5.1

The footage multiplied by the standard material required figured as above, gives the amount required for the table.

This method of figuring finishing material is subject to proof by test runs. An inventory of finishing material on the floor is taken at the beginning of the run. A record is then kept of the total number of units finished during a fixed period. At the end of the period another inventory is taken and the actual amount of material consumed figured as follows:

Inventory first of period	000.00
Plus Material Requisitioned	0,000.00
Total	0,000.00
Less Inventory end of period	000.00
Equals Material Consumption	0,000.00

This consumption figure may be checked against the estimate and a waste percentage ascertained.

Corrected to ______ 19 ___

MATERIAL SUMMARY

TABLE NO. ______

LUMBER													FINISHING MATERIAL											
PART	No.	L	W	T	Board Feet	Material	Price	Cost	Price	Cost	Price	Cost	Surface	Material	Quan.	Price	Cost	Quan.	Price	Cost	Quan.	Price	Cost

HARDWARE AND MISC.				VENEER								PACKING MATERIAL				
Material	Quan.	Price	Cost	Material	Feet	Price	Cost	Price	Cost	Price	Cost	No.	Material	Quantity	Price	Cost

FIGURE 153.—Form for Material Summary

Details of Cost Compilation

Material. A material summary card (Figure 153) is filled out for each unit of product giving in detail the quantity of material required. Under Lumber, Veneer and Finishing Material separate columns have been provided for use in figuring the material cost of tables in three different finishes. The quantity of material should be entered in ink. The price and value should be extended in pencil to facilitate changes necessitated by variations in the market values of material.

The amount of labor and hardware required for a unit may be readily ascertained. The amount of glue is figured from the number of square feet glued. The amount of finishing material is estimated from the surface feet to be finished as follows: Test runs are made for each of the finishing operations and from these tests the amount of material necessary to cover one surface foot is ascertained in decimals of a gallon. The surface required to be covered for a table is recapped as follows:

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The footage multiplied by the standard material required figured as above, gives the amount required for the table.

This method of figuring finishing material is subject to proof by test runs. An inventory of finishing material on the floor is taken at the beginning of the run. A record is then kept of the total number of units finished during a fixed period. At the end of the period another inventory is taken and the actual amount of material consumed figured as follows:

Inventory first of period	000.00
Plus Material Requisitioned	0,000.00
Total	0,000.00
Less Inventory end of period	000.00
Equals Material Consumption	0,000.00

This consumption figure may be checked against the estimate waste percentage ascertained.

Corrected to__________19____ **MATERIAL SUMMARY** TABLE NO.________

LUMBER													FINISHING MATERIAL											
PART	No.	L	W	T	Board Feet	Material	Price	Cost	Price	Cost	Price	Cost	Surface	Material	Quan.	Price	Cost	Quan.	Price	Cost	Quan.	Price	Cost

HARDWARE AND MISC.				VENEER								PACKING MATERIAL				
Material	Quan.	Price	Cost	Material	Feet	Price	Cost	Price	Cost	Price	Cost	No.	Material	Quantity	Price	Cost

FIGURE 153.—Form for Material Summary

Lumber waste is figured as follows: The amount of lumber cut during a fixed period is compared with the amount required to fill orders during that period, care being taken to have [illegible] at the beginning of the run.

As described in the preceding section, errors in quantity of lumber cut are reported to the [illegible]. Where any overrun is reported [illegible] and any shortage made up. This [illegible] to provide [illegible] waste figure without the [illegible] after each operation. Veneer waste is obtained in a similar manner.

All lumber waste is figured upon the rough size of parts as it is impracticable and unnecessary to figure the lumber contents of the irregular finished parts.

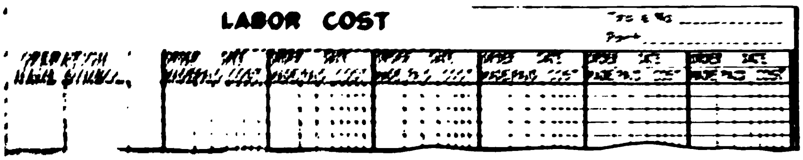

FIGURE 154. Form for Labor Cost Card

Labor. The procedure of accumulating labor costs is given briefly, as follows: As the time cards come in they are extended to show labor cost and sorted and filed by unit and part symbols. When an order is completed the cards are removed from the file, sorted by operations, and added to obtain (1) Labor Cost, (2) Quantity Produced. These amounts are then posted to a labor cost card (Figure 154), one of which is made out for each part. These cards are provided with columns for the description and symbol of the operations, to be filled in from the layout sheets and for the quantity, total cost, and cost each for every operation. In general the cost for each operation is obtained by dividing the total cost by the quantity produced, and the labor cost of parts by adding the cost of the various operations, however, the following exceptions must be noted:

Cutting off. The labor cost of cutting off lumber is figured by board feet, as follows:

Lumber cut (from requisitions)	00.000
Less waste per cent	0.000
Lumber in parts cut	00.000

The amount thus obtained is divided into the labor cost of cutting as obtained by adding the time cards turned in during the run, and the cost of cutting off per thousand board feet is obtained. Note that the waste percentage figure, used in figuring lumber, is designed to be *added* to the lumber in tables, while the waste used above is to be *deducted* from the lumber cut. The percentages will, therefore, not be the same. For instance:

Lumber in tables	1000 feet
Waste 25 per cent	250 feet
	1250 feet
Rough Lumber	1250 feet
Waste 20 per cent	250 feet
Usable Lumber	1000 feet

In other words, 20 per cent off is equivalent to 25 per cent on, and this difference must be taken into account in all material figures.

This standard cutting-off cost having been obtained, the cost of cutting-off each part is obtained by multiplying the standard cost per board foot by the number of board feet in the rough part. This is not always practical, however, for often the actual cost of cutting different kinds of lumber is taken directly from the job-time cards.

Ripping, Skinning and Planing, Jointing. As stated in the preceding section, an order is kept intact until it passes through the glue room. The cost per piece of the foregoing operations may, therefore, be obtained by adding the amounts on the time cards and dividing by the number of pieces made in the glue room.

It is not practicable to figure an order cost up to this point, as the number of pieces of lumber ripped and put through the skinner and planer will be greater than the number in the finished part. From this point on, however, the labor costs may be accumulated by orders and by parts.

Care must be taken here, as at all points, to correctly figure the cost of parts, several of which are cut from one block. In this case the labor cost of each block must be divided by the number of pieces to be cut therefrom.

After leaving the glue room there is a tendency for orders

TOTAL UNIT COST

TABLE No.______

Date											
Order No.											
Quantity Made											
Lumber											
Lumber Waste											
Veneer											
Veneer Waste											
Finish. Material											
Finish. Mat. Waste											
Hardware, etc.											
Packing Material											
Total Material											
Machining											
Veneering											
Assembling											
Finishing											
Packing											
Material											
Total Labor											

Burden												
Factory Cost												
Job Discount												
Freight												
Profit												
Selling Price												

FIGURE 155.—Form for Summarizing Material and Labor Costs

to become mixed, or diverted, and the labor cost on large orders is best determined by dividing the total labor cost as obtained by adding the amounts shown on time cards, by the total pieces produced as shown on the same cards.

When more than one man works on a machine, the quantity produced will be shown on the helper's card *in red* to prevent duplication in figuring amount produced.

The labor cost of each part having been obtained, the labor cost of the table is secured by summarizing the labor cost of

DIRECT LABOR COST PER PART — PART SYM. — WOOD

OPERATION	ESTIMATE			JAN.			FEB.			MARCH			APRIL			MAY			JUNE		
	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST
TOTAL COST PER PART																					

OPERATION	ESTIMATE			JULY			AUG.			SEPT.			OCT.			NOV.			DEC		
	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST	PROD	PAY	COST
TOTAL COST PER PART																					

FIGURE 156.—Form for Direct Labor Cost for an Individual Part

parts on a separate (red) card (Figure 154), the cost of stock parts being obtained from the cost card for the part used. A separate record is made of machining, finishing, assembling and packing labor cost.

Total Cost. The labor cost having been figured, a card (Figure 155) is filled out summarizing the material and labor costs. To these is added a predetermined per cent of the labor to cover the factory overhead or burden. The total of these three items make up the factory cost of the table. A predetermined percentage of the entire factory cost is then added to cover administrative cost or burden, an allowance made to cover job discount, and the net profit on each table figured.

PROVED COSTS

The costs arrived at on these summary cards (Figures 153,

154 and 155) since they are made up of various summaries, recapitulation, etc., of the job-time cards and material requisitions, the same fundamental records from which is posted the works ledger, and which is, we saw above, verified and proved through the controlling accounts by the private ledger, are, in the opinion of the author, as near real proved costs as it is practical to obtain for the woodworking industry.

Furthermore, the preparation of these costs requires but one cost clerk in addition to the personnel of the Planning Department,

TOTAL COST PER CHAIR — WOOD — FINISH — CHAIR

	EST. COST	JAN	FEB	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
QUANTITY MADE													
ASSEMBLE & CLEAN													
TOTAL MILL LABOR													
FINISHING "													
PACKING "													
UPHOLSTERING "													
TOTAL DIRECT LABOR													
MILL BURDEN													
FIN., UPH., PACK. "													
REED & CANE "													
LUMBER, FORWARDED													
MISC. & HARDWARE													
APPOR DEPREC. M. & H.													
FINISHING MAT. FORWARDED													
PACKING MATERIAL FORWAR'D													
UPHOLSTERING MATERIAL													
APP. OR DEPRE. "													
TOTAL FACTORY COST													
GEN ADMIN & SELLING COST													
TOTAL COST PER 100													
COST PER DOZ													
SELLING PRICE PER DOZ.													
PROFIT PER DOZ.													

FIGURE 157.—Form for Total Cost Per Chair

ment, as described in a previous section. This is made possible through the unification of production and cost records. In other words, the function of the control exerted by the Planning Department not only endeavors to effectively control the operation of the plant, but obtains its necessary production records in such a manner that a basis for costs is furnished without the expense of accumulating additional special records.

Where the operation of the plan is somewhat difficult to check and control, it is necessary to obtain the cost not by orders as is shown in the summaries given in Figures 153, 154 and 155, but to obtain the labor cost by operations, over certain periods, as for example, by months. For this purpose the set of forms

shown in Figures 156, 157, and 158 are useful. The job-time cards are sorted by parts and operation and for each part of a unit of product a direct labor-cost accumulation card similar to that shown in Figure 156 is used. The total number of parts handled on each operation is divided into the total cost of performing this operation as shown on the job-time cards and posted against the proper operation as listed in the left hand column of the form. This is very valuable as a basis for comparing the cost by operations monthly, and reflects the efficiency of operation of the factory as a whole better than when these operational

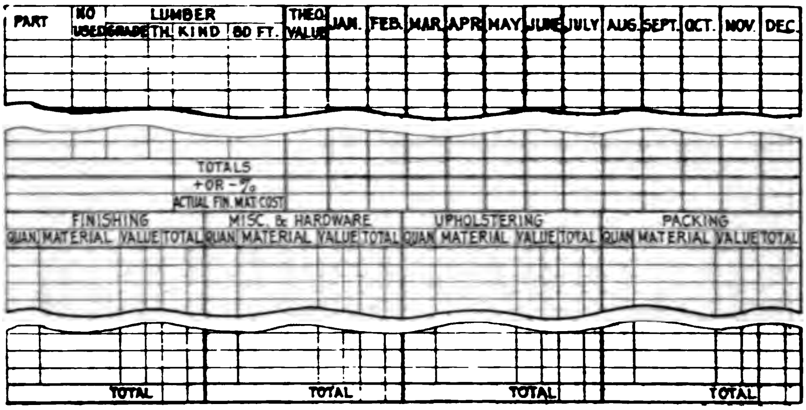

FIGURE 158.—Reverse of Form for Total Cost Per Chair

efficiencies are split up and recorded by orders. Finally, at the end of each month, the total unit cost by operations is listed on the front of the total cost per unit form as shown in Figure 157, the operations being listed in the column at the left and the necessary burden and miscellaneous department items of labor accumulated into the total. On the reverse of the form shown in Figure 158 the total cost of materials is obtained. It should be noted that provision is made for covering the fluctuation of lumber cost on this form because of changes in price or variations in waste percentage.

In either case, that is, whether costs are obtained by orders or by operations, the cost figures should be analyzed to reflect not only true cost for the determination of selling prices, as well as monthly financial statements, but to reflect operating efficiency. Any increase in material cost on an item should be analyzed to

determine whether it is due to market fluctuation or to inefficient utilization of material. All labor cost increases should also be traced down to the operation and when possible the operative responsible, and steps taken to prevent a recurrence. In general, *costs should be a lever to control the effectuality of a business rather than a history of past performances.*

CHAPTER XVI

RESULTS TO BE EXPECTED BY APPLICATION OF METHODS OUTLINED

AN old adage tells us that we obtain from any endeavor only a return proportionate to the effort put into it. Just as this applies to practically every phase of human endeavor, so does it apply to reorganization work. While the training and experience of an industrial engineer are unquestionably important factors in the ultimate success of the reorganization of a business, even more largely does the attitude of and the effort made by the client affect the ultimate success.

A manufacturer should not consider the application of scientific management to his business until he secures a reorganization engineer in whom he is willing to place his entire confidence. Unfortunately, industrial engineering is in many ways not considered a true branch of legitimate consulting engineering, largely for the reason that during past years the profession has been exploited for commercial purposes by firms of so-called engineers, the majority of whose staffs have no real practical engineering training. A legitimate industrial engineer, however, should be trusted with the reorganization of a business in the same manner that a physician is trusted with the life of his patient during an illness.

However, simply blindly putting the matter of reorganization into the hands of an engineer is not sufficient. Although the most serious retarding effect upon the work is executed by the client who consistently doubts and questions and opposes the suggestions of the engineer, for the successful carrying out of reorganization, a spirit of close association and mutual advice should exist between the client and engineer. In every business there are certain local conditions which the client can make clear to the engineer far quicker than if they are left to be discovered during the actual reorganization, when they may cause retardation and necessitate several changes in policy.

It is rather difficult to define the proper relation between client and engineer compatible with ideal conditions, but the two opposite extremes may be defined. First, the client who gives the engineer *carte blanche,* and second, the client who allows his superintendent, often a man of limited education, intelligence and breadth of view, power to pass off-hand destructive judgment upon the recommendations of a trained engineer with years of experience in the industry.

It may seem that these two extremes would never be encountered, but the author some five years ago was forced to install a plan of management for a concern where neither the president or superintendent would consult or advise with him, simply requiring that he put in whatever he thought best, based upon his own opinion of local conditions. As a result, a considerable number of changes had to be made before the method employed was really workable, and the client told the author, "I knew it wouldn't work" whenever such a change was made. In another instance, the client allowed a superintendent who had obviously nearly run the business into bankruptcy through his ineffectual management of the factory, to publicly criticise within the plant the actions taken by the author, and finally, when the methods began to demonstrate by their own effectuality that the author was correct, the client again accepted the judgment of the superintendent in his second set of attacks, wherein he maintained that while the work was all right in its results, that it had taken longer than necessary and that the author's assistants had not worked as effectively as they should.

Considering, therefore, that the attitude of the client himself is an important influencing factor upon the effectuality of the work, it is difficult to give any average results to be expected from service engaged in installing methods as outlined in previous sections. Also, of course, all results are largely dependent upon the original condition of the local labor and physical equipment of the plant encountered. The following figures, however, are based upon several years' experience in the woodworking industry covering a wide range of installation on practically every type of wood products.

The average woodworking industry is rarely more than 50 to 70 per cent effectual. Proper application of management methods to industries in these conditions result in raising the effectuality to from 90 to 95 per cent, with a resultant saving of from 15 to 30 per cent of the direct labor payroll. The entire saving

is not by any means direct labor alone, but the author has tabulated results in terms of percentage of this tangible factor.

As to the cost of such service, this depends very largely upon local labor conditions and the physical condition of the plant and equipment. But a mean average of the usual conditioned woodworking plants has shown that the cost of such installations ranges from $50 per capita of the entire personnel of an industry consisting of say 200 people, down to $25 per capita for a plant of 1000 or more. In the majority of such installations

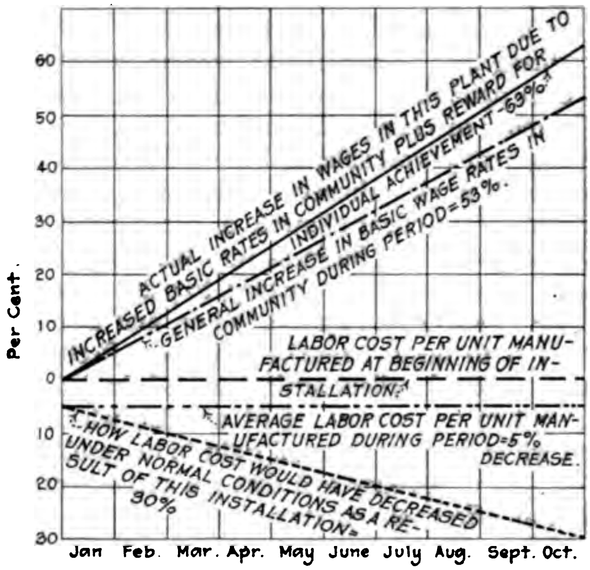

FIGURE 159.—Graph Showing Actual Results in Reducing Labor Costs and Increasing Wages in a Wood-working Plant

carried out by the author, the annual savings realized in from one to one and a half years after the methods are working properly, cover the entire cost of the reorganization. As to the time required, the complete changes can rarely be accomplished in less than a year's time, and in the average traditionally managed woodworking plant, they can be installed more effectually in eighteen months, as any attempt to rush changes is abortive.

An example of actual results is shown in Figure 159. In this plant the installation was carried out from June, 1917, to December, 1918, during a particularly difficult labor period in the middle west. The results obtained from January, 1918, when

results began to be realized, are shown in the ideal chart from which the various fluctuations have been eliminated. During this period wages were increased 63 per cent, although in the local community basic wages increased only 53 per cent, thus satisfying the labor. Labor cost was reduced approximately 5 per cent during the period, which means, that in a normal period without the large increase in local base rates, a cost reduction of 30 per cent would have been realized. In this particular plant, the attitude of the client was unusually fine and the equipment in a very good condition at the start. But considering the difficulty of the local labor situation, the author believes that this result is a fair example of what is possible to obtain by the proper installation of the fundamentals of scientific management to the woodworking industry.

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